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REVIEWS



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SPACEFLIGHT

Volume 1

JULY 1957

Number 4

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COVER

A well-planned housing settlement, with comfortable homes for workers, are features of the unique township of Woomera.

Photograph by W. Bhindle. By courtesy of the Australian News and Information Bureau.

Editorial

The present time is a particularly important one, as we have just entered upon perhaps the greatest scientific co-operative effort of all time: the International Geophysical Year. It is therefore fitting that we should present an article outlining the I.G.Y. activities which have a particular bearing on space-flight, and this has been written for us by K. W. Gatland, who is too well-known to all members of the British Interplanetary Society to need any introduction from me (or anyone else). It is also gratifying to be able to publish an article from someone who has been to the American research centres—in this case Arthur C. Clarke, who has emerged from his underwater explorations and has written a most fascinating account of what he has seen and heard in the United States. Few people can have failed to read at least some of the works of this most popular of all “astronautical” authors; this is his first contribution to SPACEFLIGHT (extracted from him, not without difficulty, by the Editor, who managed to arrest him during his comet-like progress through London *en route* for some far corner of the globe), but we are entitled to hope that it will be very far from his last, and that he will find the development of spaceships more alluring than the contemplation of flatfish in the ocean depths.

For the first time, the British Interplanetary Society has an observatory of its own. This is being erected at Harlow Hill, near Harrogate, by the members of the Yorkshire Branch; and Leonard Strickson, as one of its

prime movers, is eminently well qualified to write about it. I had the pleasure of visiting the branch last winter, and well remember my efforts to find a suitable spot from which to photograph the Tower. Finally, balancing precariously on a wall, I did manage to focus my box Brownie, and secured the picture reproduced on page 143.

We are privileged to present the article on accelerations written for us by Flight-Lieutenant M. Kennedy Browne, of the R.A.F. Institute of Aviation Medicine, at Farnborough, and I must record my thanks to Wing-Commander F. Latham, who originally put me in touch with Flight-Lieutenant Browne. Our other rocket-article author, M. F. Allward, is a prominent figure in the B.I.S. It is particularly welcome to have an article on *British* research; so much is heard of American work, and so much is not heard of Russian work, that we sometimes forget that we have research establishments of our own. Geoffrey Turner has again provided a sky diary, and our resident cartoonists, David Hardy, R. F. Chapman and S. W. Greenwood, have been joined by R. D. Miller and Peter J. Cattermole.

One mildly disappointing feature is that we have had very few letters for publication in our Correspondence Column; if you have anything to say, or any “hares” to start, I hope you will write and let us know. Articles and news features will, as always, be welcomed, and will be given full consideration by the Editorial Board.

PATRICK MOORE, *Editor*.

Informal Meetings

Although no official meetings of the B.I.S. are held during the summer months, some informal gatherings have, as usual, been arranged. The dates are July 13 and August 17; the time, 6.30 p.m. onwards; the place, the Masons Arms, Maddox Street, London, W.1. Refreshments will be available.

No definite programmes have been arranged, but it may be possible to see some new films and to have news of recent developments in general. In any case, these informal gatherings are always enjoyable, and it is hoped that many members will be able to come this year.

P. M.

Exhibition

An exhibition of rocket components and instruments will be held at the College of Aeronautics, Cranfield, Bletchley, Bucks., on Saturday, July 20, 11 a.m.–5.30 p.m. This exhibition follows the symposium on high-altitude and satellite rockets which is being organized by the Royal Aeronautical Society, the British Interplanetary Society and the College of Aeronautics. All members of the B.I.S., and their friends, are cordially invited. Bring your own transport, as the College lies in the country. It is regretted that refreshments cannot be provided.

S. W. G.

The British Interplanetary Society was founded in 1933 to promote the development of interplanetary exploration and communication by the study of rocket engineering, astronomy and other associated sciences. It now includes among its members many British and foreign workers prominent in these fields.

The Society organizes meetings, lectures, exhibitions and film shows. These programmes are planned not only to assist the spread of technical knowledge, but to stress the limitless possibilities of rocket propulsion, and in particular the ultimate implications to human society of the crossing of space.

The Journal of the Society is published quarterly, and is issued free to members. Full particulars of membership can be obtained from the Secretary. The Secretarial Address is: 12 Bessborough Gardens, London, S.W.1; telephone TATe Gallery 9371.

Opinions expressed in signed articles are those of contributors, and do not necessarily reflect the views of the British Interplanetary Society unless such is expressly stated to be the case.

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Visit to Vanguard

By ARTHUR C. CLARKE

A personal account from the United States

During a recent six-month's lecture tour of the United States, I had the opportunity of visiting most of the contractors and agencies involved in the Earth Satellite Programme—the Glenn L. Martin Company at Baltimore, the Aerojet-General Corporation at Azusa, the General Electric Company at Cincinnati, and the Naval Research Laboratory, the National Academy of Science and the National Science Foundation, all at Washington. As Project Vanguard has already been fully described in these pages, I will say nothing about its technical details here, but will try, instead to convey some of the overall impressions I obtained from my visit.

With today's techniques in rocket engineering, there is no great difficulty in establishing *some* sort of satellite in an orbit round the Earth. But to put up one which will be scientifically useful, and above all to do it by a definite deadline—that is a very different matter indeed. It is not surprising, therefore, that many of the key people on the project are developing slightly anxious expressions. They are perfectly confident that they will do the job and that there will be no major snags, but they would be much happier if they had about twice the time they have been given to deliver the goods.

After working for years on military applications of rockets, many of the engineers I met were obviously delighted to have the opportunity of doing something which would be of value to humanity as a whole, and which would have no direct warlike uses. Several times I was reprimanded when I absent-mindedly used the word "missile" when speaking of the Vanguard rocket. "It isn't a missile," I was told firmly. "It's a *vehicle*."

Perhaps it is this term which has misled those enthusiasts who have written asking if they can *pilot* Vanguard. There have been quite a number of such requests, and I suggested helpfully that they should be answered by a form letter along these lines: "Dear Sir/Madam: We are interested in your proposal, and would be glad if you would forward more particulars about yourself *provided that* you (a) are less than 20 inches high, (b) weigh less than 20 pounds. . . ."

The most entertaining of these offers came from a gentleman who (so a senior I.G.Y. official swore to me) gave a long list of the reasons why he was peculiarly qualified to be a Vanguard pilot, concluding with the statement: "I am specially suited for this work because I have highly developed ESP (extra-sexual perception)."

It was not until I stood below the towering gantry which Martin have built at their Baltimore plant to hold two Vanguards side by side, that I realized just how big the rocket is. It is one thing to say that the vehicle is 71 feet

high—quite another to climb up through the labyrinth of girders until you reach the uppermost servicing platform. When I visited Baltimore the gantry was holding the last of the Vikings—Number 14, now rechristened Test Vehicle One. Test Vehicle Zero (Viking 13) had been launched from Cape Canaveral, Florida, in December, 1956, to test, amongst other things, the Vanguard guidance system and the operation of the Minitrack transmitter which the satellite will carry. The test had been extremely successful and everything had gone according to plan. But I am a little puzzled at the change of name from Viking 13. Are rocket engineers superstitious?

Another point which I had not fully appreciated before seeing the handling arrangements of the Vanguard vehicle is its extreme fragility and the extraordinary precautions required in moving and erecting it. A single deep scratch in the metal of a propellant tank would render it useless, and the whole structure is so lightly built that any undue lateral stresses would easily cause it to bend or even to snap. As a consequence of this, special cradles or dollies have been constructed, gripping the vehicle at various points along its length so that it may be moved safely from place to place.

It will be a nervous business working near the Vanguard rocket when it stands unsupported on its firing platform during the moments before take-off—particularly if any wind springs up. Because of its unusual thinness, the vehicle will not be very much more stable than a telegraph pole balanced on its base—and as it holds several tons of violently reactive chemicals the effects of a sudden gust are terrifying to contemplate. Needless to say, detailed instructions have been prepared for the handling crews so that they will know at what wind velocities the rocket must be clamped in the filled and unfilled states.

While at Martin, I took the opportunity of visiting its recently formed subsidiary RIAS (Research Institute for Advanced Studies) which has been somewhat in the news owing to (often highly misinformed) reports concerning work on "gravity control". RIAS is one of several U.S. organizations engaged on fundamental research into gravity; there is a feeling among the scientists concerned that it is about time that *someone* had a good look at this baffling force with the mathematical and scientific tools now available, but I met no-one who seriously believed that the work would have any immediate practical results. Next to Martin, who are the designers and main contractors for the Vanguard vehicle, the other industrial organization chiefly concerned is the Aerojet-General Corporation of Azusa, California. Aerojet is providing

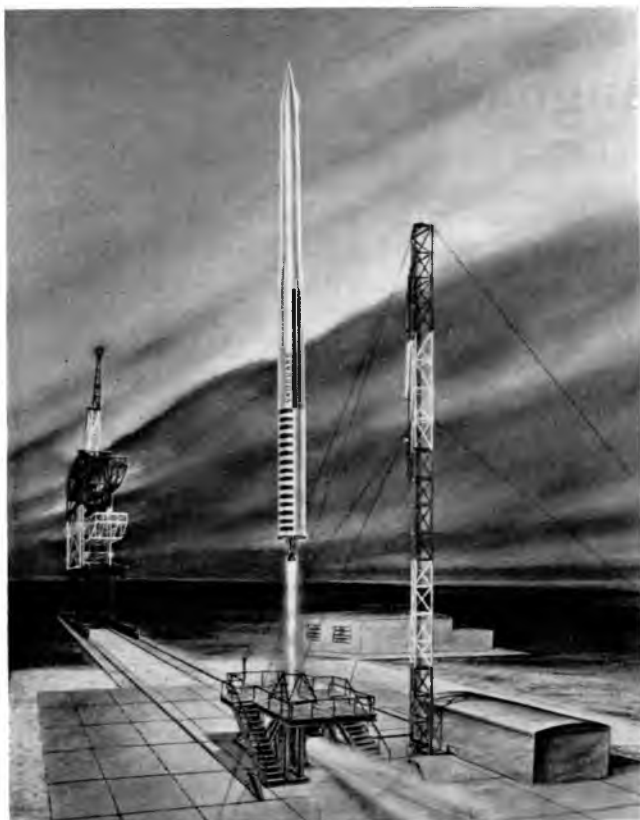


FIG. 1. "Vanguard" being prepared for take-off—an artists' impression

By courtesy of Glenn L. Martin Ltd.

the motor and tankage for the second stage, which will owe much to the well-known Aerobee design—just as the first stage owes much to Viking. The fact does not seem to have been published before that in 1954-5 Aerojet produced a proposal for a 3-stage satellite vehicle based on Bomarc, Aerobee and a solid-propellant final stage. This proposal, like the Army's Project Orbiter (based on Redstone) is another of the big "ifs" of satellite history.



FIG. 2. "Vanguard" at the moment of take-off—an artists' impression

By courtesy of Glenn L. Martin Ltd.

I must confess that at Aerojet I was somewhat sidetracked by the intriguing little one- and two-man pedal-operated submarines the Corporation has built as a by-product of its extensive underwater propulsion activities. These plastic "Minisubs" are completely flooded, the occupant(s) using frogman gear and so being able to leave or enter at will. I was not able, unfortunately, to persuade Aerojet to lend me one for exhaustive tropical trials.



FIG. 3. Part of the Minitrack antenna layout at the U.S. Naval Research Laboratory's satellite tracking station, Blossom Point, Maryland

By courtesy of the U.S. Naval Research Laboratory

A major responsibility for the Vanguard project lies on the broad shoulders of the General Electric Company, builders of the first-stage motor—the X 405. When I was at Cincinnati, GE kindly presented me with an elegant pair of cuff-links bearing an accurate model of this motor—down to turbine pumps and plumbing. As a result I was able to create a mild sensation at lectures by saying, “I happen to have with me a couple of solid silver models of the satellite vehicle’s first-stage motor...”

While on the subject of lectures I cannot omit an incident that occurred in (of course) California. After almost every talk I was asked for my views on flying saucers, and invariably gave the same answer—i.e. that I’d seen about six, had questioned a good many eye-witnesses, and was therefore no longer particularly interested in them as they were fairly obviously *not* of interplanetary origin and in most cases not even artifacts. This frequently roused the ire of the Faithful, and on this particular occasion a lady rose from the audience and said plaintively, “Do you mean to say that all the people who claim to have met men from saucers are liars?” To such a direct question I could only give the equally direct answer, “Yes, Madam,” whereupon she subsided abruptly. After the lecture the chairman, with great glee, informed me that my interrogator’s husband was the author of one of the best-known of the Sacred Writings; I leave you to guess which.

Returning to more serious subjects, I was particularly gratified when my tour took me to Roswell, New Mexico, where I was able to visit the local museum and to see some pages of Dr. Goddard’s notebooks containing 30-year-old speculations about atomic energy. Goddard’s original launching tower has been moved into town and now stands outside the museum—a strange apparition to see beside a main street. The New Mexican climate has treated it lightly; jet burns are still visible on the concrete counter-weights and it looks as if Goddard had stopped work only a couple of days ago.

It was at Roswell that I had an encounter which will make all amateur (and many professional) astronomers green with envy. After I had addressed the New Mexico Military Institute, one of the cadets approached me and

asked if I would like to see his photographs of Mars. As I knew perfectly well that it was impossible to photograph Mars except with a really large telescope, I did not take this very seriously. I was astonished, therefore, to be shown images about half an inch across, on which I could make out quite clearly the great dust storm which had obscured visibility during the 1956 opposition. When I asked how these had been taken, the young astronomer diffidently produced an issue of *Sky and Telescope* showing a photograph of his commercially-built observatory—with its 20-in. reflector and its 10-in. refractor. The whole installation, I guessed, would not have left much change from \$50,000, and I think we will be hearing more of Mr. Morgan—particularly as the Lowell Observatory is shifting him *and* his instruments to Flagstaff.

While on the subject of Mars, I was able to attend the Symposium arranged in New York by the American Museum of Natural History, at which astronomers reported the results of their 1956 observations. On the whole, the Opposition was a great disappointment; the weather on Mars was not co-operative and little really new was learned. The same thing happened at the last Opposition; if the clouds roll up again in 1971, we will have a right to be suspicious.

But to return to my encounters with Vanguard. Looking back on the experience, my main impression is still one of slight incredulity that the whole programme is actually taking place, and is not a piece of science-fiction. (Please note the omission of the qualifying adjective “mere” with which most respectable critics carefully label the *genre*.) Despite all the publicity the project has received, I am quite certain that this is an almost universal reaction. The general public seems to have very little idea of what is going on and what will be achieved in the near future, because the figures of speed and altitude are so outside the range of ordinary experience that they simply fail to register. If this is the case—as I think it is—then a great many people are going to have a shock in a year or so, when the American satellites start racing overhead from west to east—and the Russian ones from north to south.



Rockets and Artificial Satellites in the I.G.Y.

By KENNETH W. GATLAND, F.R.A.S.

The scope and objectives of the I.G.Y. with background histories of the rockets and artificial satellites that will play vital rôles in this exciting exploration

This month marks the beginning of the International Geophysical Year—the biggest and most intensive programme of research ever attempted by man. Between July 1, 1957 and December 31, 1958, more than 5,000 scientists and engineers from 54 nations will combine their talents and resources in a concerted effort to learn as much as possible about the Earth on which we live and the factors that affect our physical environment, compressing into the space of 18 months studies that might otherwise occupy a quarter of a century. One of the most heartening aspects of this world enterprise is that no barriers are being placed in the way of co-operation between scientists of East and West. Much is anticipated, for example, from the launching of the first artificial satellites, in which keen competition is likely between Russia and the United States. Needless to say, these activities will have the greatest possible significance for astronautics, but their glamour should not be allowed to detract from other important research programmes.

Research Objectives

The I.G.Y. has as its overall objective the exploration and measurement of all the large-scale aspects of the Earth, its major land and sea areas, the Earth's core and crust, the deep ocean currents, the tides, weather and climate, the high atmosphere and surrounding space. What do these studies hope to achieve? Apart from improving our understanding of the physical environment, they are expected to have much more than academic interest. One possible result is improved radio communications arising from improved knowledge of the electrified layers of air high above the Earth (the ionosphere) which reflect radio waves. For many years, it has been known that disturbances in the ionosphere, and consequent breakdown of long-range radio communications, coincide with disturbances on the Sun, which may have serious consequences for shipping and aircraft. A case in point arose last year when a radio "black-out" caused a British submarine operating off the Greenland coast to be reported missing.

Intense solar flares are always accompanied by a sudden fade-out of short-wave radio communications over the sunlit half of the globe, due to the greatly increased amount of ultra-violet radiation reaching the Earth, with the result that, instead of being reflected back to the ground, the radio waves are absorbed.

If solar activities responsible for these effects can be predicted and the nature of their influence on the ionosphere better understood, ways may be found of improving

long-distance radio techniques. One reason why 1957–58 was chosen for the I.G.Y. is that it coincides with the time when activity on the Sun is expected to reach a maximum. At such times, magnetic storms and auroral displays are also more numerous.

Another important field in which I.G.Y. scientists will be active is glaciology. One per cent. of the world's water supply is locked up in the thick ice fields which cover one-tenth of the Earth's surface. There has been a growing conviction among scientists this century that the Earth's climate is slowly changing, a process which, one day, might alter the distribution of the world's vast desert and fertile regions. Some authorities believe that astronomical causes are responsible for the fluctuations in climatic conditions that in centuries past caused the Ice Ages. Today, the trend appears to be towards warmer conditions, which ultimately could lead to shipping in the presently ice-locked ports of the far north and, conceivably, to flooding of important coastal cities.

Another important sphere of interest is meteorology. Although three-quarters of the Earth's surface is water, efforts have so far failed to produce any appreciable change in the distribution of rainfall and mankind still experiences shortages. One of the great hopes of the I.G.Y. is that the mechanics of the weather, and the grand cycle which carries water from ocean to atmosphere to land and back to ocean—upon which world agriculture depends—can be better understood, and possibly further man's hope of controlling the weather. This would tie in with rain-making research being pursued in many parts of the world.

The shape and dimensions of the Earth, still not accurately known, are other fields of study. One of the principal reasons why *geodesy*, as the science is called, is not more advanced is that our knowledge of the strength of gravity over vast areas of the ocean, especially the Arctic and Antarctic, is limited.

In their experiments with artificial satellites, scientists hope to discover the strength of the Earth's gravitational pull in remote, uncharted, areas—and hence the corresponding crustal mass—by measuring the slight distortions which are expected to be made on the satellite's orbit. Measurements of inter-continental distances include the use of the Earth's natural satellite, the Moon, as a triangulation point. Long-term studies of this nature, by the precise location of reference points on the Earth's surface, will also determine whether or not the land masses actually drift, as some authorities believe possible.

One of the artificial satellite's less passive rôles will be the investigation of cosmic rays before they are filtered



VANGUARD SATELLITE VEHICLE (U.S.A.)



VANGUARD 3rd STAGE
& ARTIFICIAL SATELLITE

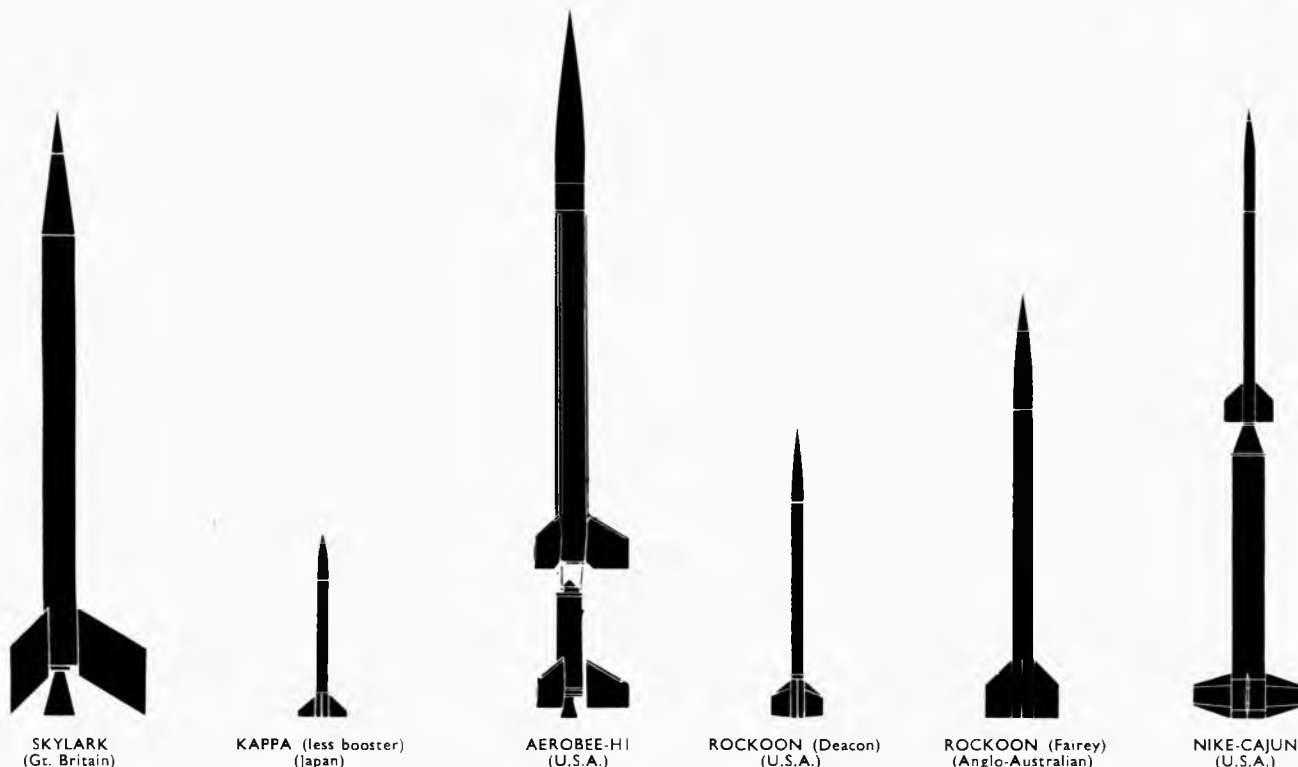


FIG. 1. Silhouettes (to scale) of rockets to be used in the I.G.Y.

and absorbed by the Earth's atmosphere. These mysterious particles bombard our world constantly from outer space with energies far greater than have ever been produced by man—yet little is known about them or whence they come. If we could be certain of their nature and origin, this would greatly improve our understanding of the underlying nature of matter, and would undoubtedly have the greatest influence in nuclear physics. Information on solar radiation beyond the atmosphere is also expected from the artificial satellites, together with data on the density of meteoric dust.

These are just a few of the more obvious research activities associated with the I.G.Y. in which dozens of different types of optical and electronic equipment will be used, ranging from cameras, telescopes, radio and radar to newer tools of scientific discovery carried in artificial satellites and the latest high-altitude rockets.

The Rôle of Rockets

In recent years, the atmosphere 50 to 150 miles about the Earth has become a vast laboratory where, with the aid of rockets, scientists have been studying a wide

variety of research problems associated with the Earth in space. So far, most of this work has taken place in the United States, and it is refreshing to learn that a high-altitude rocket has at last been built in this country. This is the Skylark, a large solid-propellant rocket which provides an interesting comparison with the liquid-propellant Aerobee, being designed to carry a payload of 50 to 150 lb. to an altitude of 100 miles.¹

Designed by the Royal Aircraft Establishment, the British rocket has an overall length of 25 ft. and a diameter of 17.4 in. It is stabilized by three fixed tail fins.

The Raven rocket motor used in Skylark is of particular interest in that it is considerably larger than any previously made in Great Britain. Developed by the Weston Division of the Bristol Aeroplane Company in association with the Rocket Propulsion Department, R.A.E., Westcott, it is an example of a very large solid-propellant motor having a long time of burning. Filled with a plastic propellant, the Raven develops a thrust of 11,500 lb. for 30 seconds, a duration which compares with some bi-propellant units.

TABLE 1
Anglo-Australian Rockets in I.G.Y.
SKYLARK I ROCKOON
(Bristol Univ. Fairy)

Length	25 ft.	18 ft.
Diameter	17½ in.	10 in.
Weight, payload	65 to 150 lb.	—
Weight, launching	2,560 lb.	—
Thrust	11,500 lb. × 30 sec. (Solid Raven motor)	—
Velocity, cut-off	Mach 5.0 (at 70,000 ft.)	—
Altitude, summit	93 miles (with 65 lb. payload)	60 miles
Launcher	181-ft. tower	60-ft. plastic balloon (rocket released at 60,000 ft.)
Number of I.G.Y. firings	Unspecified	Unspecified
Vehicle cost	£5,000	—

The motor case, made from chrome molybdenum steel, has a nominal wall thickness of 0.014 in. and withstands a test pressure of 1,420 lb./sq. in. It is manufactured either by wrapping and welding sheet steel or by welding together lengths of drawn steel tube. The head and rear ends of the motor are machined from forgings and are welded to the body; to save weight—a factor of extreme importance—the venturi is formed as a high-pressure moulding in Durestos, a phenolic resin-impregnated asbestos.

The first static test of the Raven motor was made at Westcott on August 3, 1956.

The Skylark launcher takes the form of a lattice tower 81 ft. high, which is pivoted near its centre from a

triangular mounting, the tripod legs being 62 ft. apart; the mounting permits a limited degree of elevation and traverse. The pivot arrangement allows movement between 15° forward of the vertical and 5° rearward of the vertical in elevation and 10° either side. Remote controlled motors situated on the pivot frame allow easy adjustment of the tower.

Fabricated largely of Bailey-bridge panels, the complete structure weighs 35 tons. A feature of the launcher is a self-loading cradle which receives the rocket on its delivery trolley and swings it into the lift well for raising to the firing position. The nose section, containing the research instruments, is fitted to the rocket in its upright position by means of servicing platforms situated around the mid-section of the tower. The launching rails have been made adjustable so that, if necessary, Aerobee could be fired; a point of further interest is that it would be possible, with slight adjustment, to launch Skylark from the Aerobee tower at Fort Churchill (situated on the western edge of Hudson Bay, Canada).

Skylark will carry telemetry, Doppler and beacon-tracking equipment in addition to research payload. Investigations to be made include the radio-reflecting ionized layers in the upper atmosphere, night airglow, wind, atmospheric temperature and pressure and measurements of the rocket's skin temperature. Most of the measurements obtained with Skylark will be telemetered continuously to ground stations during the flight. The rocket will break up in its descent into the lower atmosphere, but in later versions it is hoped that apparatus carrying permanent records, such as cameras and spectroscopes, can be parachuted to the ground and recovered.

TABLE 2
U.S. Rockets in I.G.Y. (with comparison of 1949 Aerobee with current Aerobee-Hi)

SUSTAINER: —	AEROBEE (AJ10-25)	AEROBEE-Hi (RV-N-136)	NIKE-CAJUN	ROCKOON (Skyhook Deacon)
Length	18 ft. 11 in.	23 ft. 7 in.	13 ft. 4½ in.	12 ft. 3 in.
Diameter	15 in.	15 in.	6½ in.	6½ in.
Weight, payload	120 to 200 lb.	120 to 200 lb.	10 to 60 lb.	20 to 30 lb.
Weight, launching	1,103 to 1,183 lb.	1,454 to 1,534 lb.	250 lb.	218 lb.
Weight, propellant	678 lb.	1,058 lb.	—	—
Weight, helium	5 lb.	7 lb.	—	—
Thrust	4,000 lb. × 34 sec.	4,100 lb. × 50 sec.	—	5,700 to 6,000 lb. × 3 to 3.5 sec.
Propellant	Red fuming nitric acid aniline and furfuryl alcohol	Red fuming nitric acid aniline and furfuryl alcohol	Solid	Solid
BOOSTER: —				
Length	6 ft. 7 in.	6 ft. 7 in.	11 ft. 3 in.	} Balloon-launched
Diameter	—	—	16½ in.	
Weight	—	—	1,324 lb.	
Thrust	18,000 lb. × 2.5 sec.	18,000 lb. × 2.5 sec.	—	} Balloon-launched
Velocity, cut-off (sustainer)	—	—	Mach 5.0 (at 5,000 ft.)	
Altitude, summit (sustainer)	80 miles (120-lb. payload)	180 miles	70 to 95 miles	
Launcher	150-ft. tower	150-ft. tower	—	68-ft. Skyhook plastic balloon (rocket-released at 79,000 ft.)
Number of I.G.Y. firings	—	—	65 (42 from Fort Churchill, from shipboard, at White Sands and Guam)	—
Vehicle cost	£10,000 to £14,000	—	£3,000	—

The R.A.E. are designing a sun-seeker to be flown in the rocket for the purpose of measuring solar radiation and obtaining ultra-violet pictures of the Sun at high-altitudes. Wind, temperature and pressure will be determined by means of grenades fired from the rocket at approximately equal intervals along the trajectory and observed from a number of ground stations.

The British experiments have been devised by a number of University Departments under the general guidance of the Royal Society's Gassiot Committee. The following is a complete list of the research which has been proposed and for which instrumentation is being constructed:

(1) Temperature and winds at altitudes in the range of 30 to 100 km., by the grenade method. Microphones will be sited at various points over a wide area. The grenade flashes will be detected by ground-based photomultipliers which will be slaved by tracking equipment during daytime firings. *University College, London.*

(2) Winds at altitudes in the range 20 to 70 km. by the radar tracking of "window" (aluminium-foil strips) released from the rocket. *Imperial College.*

(3) The sodium vapour experiment. The sodium emission will be studied by an interferometric method. *Queen's University, Belfast.*

(4) Day and night airglow. A group of five photomultiplier tubes will be flown under a jettisonable nose-cone, and filters will be used to restrict measurement first to the oxygen green line and later to the oxygen red line. *Queen's University, Belfast.*

(5) Ion mass-spectrometer. A mass spectrometer probe will be carried under a jettisoning nose on an extendable support, and will be used to measure the nature and abundance of atmospheric ions. *University College, London.*

(6) Absolute concentrations of electrons and ions. Details have still to be decided, but in principle the proposal is to apply a voltage pulse between two probes and to measure the resulting pulses of electrons and positive ions. *University of Birmingham.*

(7) Electron densities by radio propagation methods. Both a C.W. method based on the Doppler tracking system, and a pulse method are being developed for the measurement of electron densities. *University College Swansea and Royal Aircraft Establishment.*

(8) Pressures and temperatures. Various types of pressure gauges are being developed; wherever possible ram and cone wall pressures will be measured in flight. *Royal Aircraft Establishment.*

The first firing of the Skylark, less research instruments, took place at the joint Anglo-Australian Weapons Research Establishment, Woomera, in February, when the rocket, fired on a low-angle trajectory to test stability characteristics, reached a height of approximately 20 miles. If progress is maintained, there is every likelihood of a number of experiments being carried out during the International Geophysical Year, not only at Woomera but also at Aberporth, South Wales. An unspecified number of Skylarks have been ordered, with a cost per rocket of about £5,000.

However, whether Skylark 1 will be used or an improved version will depend on the result of further trials. It appears doubtful whether the original rocket will reach its full design performance, because the initial thrust is insufficient to reduce dispersion to a satisfactory amount, a situation which might easily have been anticipated in view of American experience with the WAC-Corporal and Aerobee, which both have boosters. For this reason, a second model is being developed to incorporate a high-thrust, short-duration boost unit

TABLE 3
Vanguard Earth Satellite Vehicle (compared with Viking 11)

	VIKING 11	1st Stage	VANGUARD 1 2nd Stage	3rd Stage
Length	45 ft.	44 ft. (overall 3-steps, 72 ft.)	31 ft.	5 ft.
Diameter	45 in.	45 in.	32 in.	20 in.
Diameter, over fins	13 ft. 3 in.		Not applicable	
Weight, payload	825 lb.	—	—	21.5 lb. (20 in. diameter satellite)
Weight, launching	15,005 lb.	22,600 lb.	—	—
Weight, propellant	11,600 lb.	—	—	—
Propellant	Liquid oxygen alcohol	Liquid oxygen gasoline-alcohol	White fuming nitric acid unsymmetrical dimethyl-hydrazine	Long duration solid
Feed system	H ₂ O ₂ turbo-pump	H ₂ O ₂ turbo-pump	Helium pressure	—
Thrust	21,000 lb. × sec.	27,000 × 140 sec.	—	—
Velocity, cut-off	6,300 ft./sec.	5,500 ft./sec.	13,400 ft. sec.	26,000 ft./sec.
Altitude, cut-off	40 miles	36 miles (separation)	140 miles	300 miles (horizontal launching)
Altitude, max.	158.4 miles	—	—	300 miles (nominal entry) 1,400 miles (max. orbital)

Provisional data: Glenn L. Martin

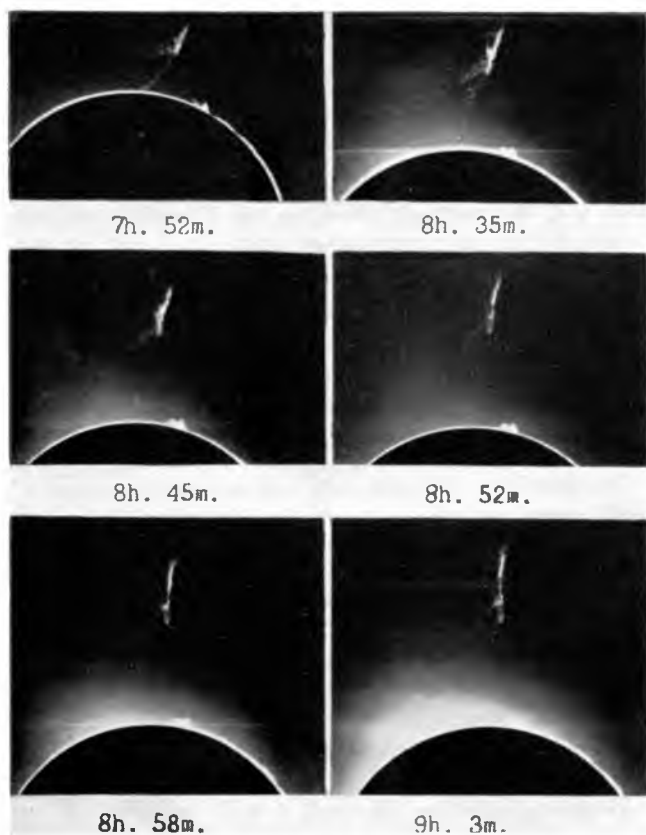


FIG. 2. A very high eruptive prominence on the Sun
(Crown Copyright, Science Museum, London)

which, it is hoped, will be available at Woomera later this year.

Anglo-Australian Rockoon

To supplement Skylark in Anglo-Australian I.G.Y. experiments, smaller rockets have been developed for launching from balloons. The rockets, approximately 18 ft. long and 10 in. diameter, are larger than any previously fired from balloons, and have been developed by the Fairey Aviation Company's Special Projects Division. Powered by a solid-propellant motor, the rockets will reach Mach numbers of between 2.0 and 3.0 when launched at 60,000 ft., and summit altitudes in the neighbourhood of 60 miles are expected.

The balloons, manufactured to the specification of Bristol University, are made of polyester material 0.0015 in. thick. Each balloon will receive 12,000 cu. ft. of hydrogen (manufactured on the site at Woomera) which will expand to about 100,000 cu. ft. at 60,000 ft., when the envelope, originally 80 ft. high and 25 ft. wide, will have become a sphere of 60 ft. diameter.

The Anglo-Australian Rockoon will carry similar research instruments to that of Skylark, with additional facilities for collecting air samples. Similar Rockoon experiments are being made in the United States during the I.G.Y. using 72-ft. diameter plastic balloons and 12-ft. Deacon rockets weighing 184 lb.

Rocket Research in Japan

The Japanese Science Council has two projects for the I.G.Y., namely Kappa and Sigma.³ The former, a two-stage solid-propellant rocket, is designed to carry a payload of 15 lb. to an altitude of 80 miles. The Sigma project, developed on the Rockoon principle, employs a plastic balloon and a small solid rocket weighing about 25 lb.

Twenty Kappa rockets variously equipped for measuring solar radiation, ion density, cosmic rays, air pressure, temperature and winds in the upper atmosphere, are scheduled to be launched at the Akita Test Centre on the northern coast of Japan, a test site specially prepared for the I.G.Y. by the University of Tokyo. Kappa follows a number of smaller rockets designed by the University, including Pencil and Baby.

Probably the world's smallest and cheapest rocket test-vehicle, Pencil is under 12 in. long, has a diameter of 0.7 in. and weighs less than half a pound. The total cost per rocket is about £2 10s. 0d. More than 150 of these miniature rockets have been fired since the research programme began in April, 1955, being used to investigate centre of gravity location, dispersion, launcher length, to compare various nozzles, propellants and tail-fins, and also to train people in optical tracking. Later, some initial experiments were made in tandem-staging by the addition of a 4-finned booster of the same diameter.

The larger Baby, first launched in August, 1955, was rather more ambitious; it had a diameter of 3.0 in. and contained 2.2 lb. of solid propellant; it was fitted with a short tandem booster. Some versions carried telemetry equipment and others a recovery system for a 16 mm. camera. Recovery of the latter over the sea entailed separating the nose-cone from the rocket motor by a pyrotechnic method, using a timer. The rocket-borne camera, together with a recovery parachute and self-inflating float, was ejected by means of a light explosive.

Both Pencil and Baby rockets have attained transonic speeds.

Nike-Cajun

One of America's big hopes for the I.G.Y. is a relative newcomer to the field of high-altitude research—Nike-Cajun.⁴ The history of this project, a two-stage solid-propellant rocket, dates from 1954 when research was being undertaken by the Pilotless Aircraft Research Division of NACA., at Langley Field, using a Nike booster-Deacon combination for achieving high Mach numbers at medium altitudes. Under the sponsorship of the Air Force Cambridge Research Centre, the University of Michigan undertook a co-operative effort with NACA to try out a high-altitude version of Nike-Deacon. Calculations showed that a steep firing angle and a coasting period between the two stages would enable the final stage to climb perhaps 400,000 ft. with a 50-lb. payload.

Two launchings were made at the NACA site at Wallops Island in June, 1955, when summit altitudes of

approximately 348,000 ft. were attained. Instrumentation consisted of a free-falling sphere to determine air density, and radar beacons for tracking.

The first Nike-Cajun rocket was fired at Wallops Island on July 6, 1956. Cajun is essentially a Deacon with a modern propellant. The complete two-stage vehicle weighs about 1,550 lb. at take-off and is 26 ft. long, the gross weight of Cajun at separation being about 250 lb. Altitudes of 100 miles have been exceeded with payloads of 60 lb.

The take-off ramp is a modified Nike launcher, and the boost phase lasts 3.3 seconds. A coasting period of 10 to 20 seconds is allowed between separation of the booster and firing of the 2nd stage to allow Cajun to outclimb the high drag region before it reaches peak velocity, though the delay must not be too long as the stabilizing fins will then not maintain an effective flight path.

So effective has the new rocket combination proved on test that when the Aerobee facility at Fort Churchill was planned, arrangements were also made to provide a fully-equipped launching site for Nike-Cajun, and 42 of these rockets will be fired at Churchill during the I.G.Y. Others are to be launched from shipboard, at White Sands, and at Guam.

The research programme includes air pressure, density and temperature, water vapour distribution, variations of the Earth's magnetic field in the E-region of the

ionosphere, and electron density in the E-layer. Some rockets will be used to photograph the optical horizon in studies of Arctic cloud structure. Yet others will carry grenades (ten 4-lb. grenades per rocket) for the measurement of atmospheric temperature and winds up to 70 miles; in this case, the total payload weight is 100 lb. In addition, the Signal Corps is using Nike-Cajun to test its planned satellite instrumentation for meteorological measurements.

Further experiments to determine air density in the upper atmosphere are also to be made, using the falling-sphere technique. An accelerometer is mounted in the 7-in. sphere which is ejected from the rocket at 180,000 ft. on the ascending path of the trajectory. Ambient density is calculated from the drag equation. The method requires telemetering only, which is accomplished with a small pulse transmitter radiating at 400 mc also carried in the sphere.

In addition to the above experiments, the State University of Iowa will fire 16 Nike-Cajuns at Churchill with instruments for measuring cosmic rays and auroral radiations. The Naval Research Laboratory will launch 16 Nike-Deacons carrying detectors for measuring X-rays during solar flares at Point Magu. Finally, the New Mexico College of Agriculture and Mechanic Arts is using the Nike-Cajun in its project of photographing hurricanes on America's east coast.

Aerobee and Aerobee-Hi

The other principal "work-horse" of the American I.G.Y. programme is Aerobee-Hi, a rather sophisticated bi-propellant rocket whose development dates back more than a decade.²

The first attempt to project recording instruments above the limit of pilotless sounding balloons (approximately 25 miles), was made in 1945 with a small American-designed rocket known as WAC-Corporal. This slim, three-finned, rocket, 16 ft. long by 12 in. in diameter, had a gross weight of 665 lb. With the assistance of a modified Tiny Tim booster, it ascended 43½ miles.

In 1946, a new high-altitude rocket was designed, similar to WAC-Corporal in general layout, but with superior performance and more space for instruments. This was Aerobee, a joint product of the Aerojet General Corporation and the Douglas Aircraft Company, with supervision from Johns Hopkins University. This bi-propellant rocket, which had an overall length of 18.8 ft. and a diameter of 15 in., was fired from a 140-ft. tower with the assistance of a solid-propellant booster. The booster jettisoned within a second of firing after accelerating Aerobee to a speed of about 1,000 ft. sec. Propulsion of the sustainer continued for 45 seconds and at the climax of thrust, the rocket's velocity was approximately 2,790 m.p.h. and the altitude about 95,000 ft. Summit altitudes of 70 to 80 miles were achieved on several occasions following the first successful firings in 1948.

Like its predecessor, the vehicle is unguided and relies on "arrow stability" derived from a high launching velocity, its three fixed fins and proper location of the



FIG. 3. Full-scale model of the first man-made satellite, to be launched during International Geophysical Year. The sphere is 20 inches in diameter and weighs 21.5 lb. A 13-ounce radio transmitter will relay data back to Earth. Some of the more important features are (A) recording-device cell operated by solar energy; (D) erosion gauge to measure impact of micro-meteorites; (5) memory unit to furnish data stored during orbit



FIG. 4. Dr. J. P. Hagen, Director of the "Vanguard" project, with a cut-away model of the artificial satellite

centre of gravity. Its trajectory is controlled simply by tilting the launching tower in accordance with wind data obtained from meteorological balloons.

Flight data were originally retrieved from the rocket by two methods: (a) radio telemetering, and (b) recovery of specially armoured equipment from the impact wreckage. Explosive separation of the nose-cone from the body of the rocket was arranged to occur at a suitable altitude on the descending path of the trajectory. The nose section, containing the instruments, was thereby made aerodynamically unstable, with the result that it tumbled to Earth relatively slowly and certain equipment, ciné-cameras, etc., was satisfactorily recovered. More recently, it has been possible to land the complete instrument compartment by ribbon-type parachute, a procedure which proved successful in the recovery of mammals in the "weightlessness" experiments conducted by the United States Air Force Aero Medical Laboratory in 1952.

The concept of the newer Aerobee-Hi⁵ dates back to 1952, when the U.S. Air Force were approached by the Aerojet-General Corporation concerning the possibility of developing an improved Aerobee rocket. Contracts for the new high-altitude vehicle were placed by the Air Force and Navy in 1952 and 1953 respectively.

The Air Force specification required a rocket which would carry a payload of 150 lb. to an altitude of 150 miles, almost double that of the original Aerobee. The increased performance entailed a drastic improvement in

the mass-ratio (gross weight dry weight) obtained by extending the fuel and oxidizer tanks to include 32 per cent. more propellant, and by fabricating the tanks themselves from a lighter type stainless-steel. These changes brought about an improvement of the mass-ratio from 3.17 to 4.62 and in April, 1955, at the very first launching, the Air Force Aerobee-Hi reached a height of 123 miles with an overweight payload of 196 lb.

The Navy specification, even harder to meet, required the rocket to carry a payload of 150 lb. to a height of 180 miles, into the F-region of the ionosphere. To achieve this the propellant capacity was increased still further, an improved light-weight combustion chamber was provided, and a chemical gas generator substituted for the heavier helium storage tank of the rocket's pressurization system. Larger tail-fins were incorporated to improve stability at the cut-off altitude.

Several models of the Navy Aerobee-Hi have been test-fired with varying degrees of success. Early difficulties were experienced with the new combustion chamber due to failure of the internal liner. This was attributed to an adverse water content in the oxidant (nitric acid), which led to a new specification for a low water-content acid, the use of which incidentally improves the performance of any Aerobee rocket.

The development of the chemical pressurizing system also suffered early setbacks, for in two test-launchings made in 1955, failures in other areas of the rocket system prevented a proper evaluation of the new technique. In the first case, Aerobee-Hi failed to ignite due to a faulty regulator and in the second, the rocket exploded just after leaving the launching tower—a failure attributed to a too abrupt starting phase complicated by low temperature.

In view of the imminence of the I.G.Y. and the need to provide reliable test-vehicles for this important programme, the solid-propellant hot-gas generator has been temporarily shelved and current models of the Navy Aerobee-Hi still embody helium gas-pressurization. A reversion was also made, beginning with RV-N-13b last year, to the standard 4,000-lb. thrust Aerobee combustion chamber after failures of the new thrust chamber. This, however, is expected to be only a temporary measure. In any event, Aerobee-Hi RV-N-13b—a complete success—reached a new record altitude of 164 miles with a 145-lb. payload, surpassing the peak altitude reached by Viking (158 miles).

Satellite Trials

Already this year, the Navy Aerobee-Hi has figured prominently in pre-Vanguard satellite trials. In April, a rocket launched from White Sands Proving Ground, New Mexico, reached a height of 126 miles with a payload comprising a prototype satellite transmitter and a number of research instruments. The miniaturized electronics were contained in an aluminium cylinder 10 in. long and 5 in. diameter. A separate telemetering set carried in the rocket gave ground observers information of the rocket's progress during the initial period of

the flight, but this was cut-out after the 51-second thrust phase, whereupon retracted antennæ extended automatically from the rocket's nose-cone, enabling the satellite transmitter to take over and report directly to ground stations. Among the information received from this flight were data on primary cosmic rays and micro-meteorites.

This firing was regarded as entirely satisfactory and many similar launchings will follow to test various components of the Vanguard satellite and its launching vehicle.

Initial trials, simulating the Vanguard first-stage, were made with Viking 13 on December 8 last year, when a General Electric rocket motor was flown in conjunction with Vanguard control equipment. Launched from Patrick Air Force Base, Florida, the Viking ascended a short distance vertically and then turned slowly toward the horizontal. The rocket reached a peak velocity of 4,000 m.p.h. and climbed to an altitude of 125 miles, ending its flight in the Atlantic. Again, the test was regarded as entirely successful.

Viking 14, also launched from Patrick Air Force Base, carried in its nose the small third-stage rocket which, in the actual Vanguard launching vehicle, will place the satellite finally in its orbit at 18,000 m.p.h. 300 miles above the Earth. The purpose of this experiment was to test separation techniques. In Vanguard, the solid-propellant rocket will be fired from a turn-table mounting in the nose of stage 2 which is set rotating by small solid rockets fired tangentially; thus, the third stage with the satellite at its head will be spin-stabilized.

Contrary to earlier reports, control after cut-off of the 2nd stage will not be obtained by an H_2O_2 steam generator, but by releasing helium pressurizing gas from the propellant tanks through control jets. This has the obvious advantage of reducing weight, since the tanks must, in any case, be highly pressurized for the propellant feed. Here is a rather good example of how, by careful and ingenious design, useful improvements can be made in the mass-ratio—a factor of paramount importance in the development of "minimum" satellite vehicles.

Full details of the Vanguard launching vehicle were given in *SPACEFLIGHT*, October, 1956, and with one exception, the development programme appears to be progressing smoothly. On April 16, it was announced that the first-stage rocket engine has failed to meet design specifications and is being re-designed. However, this is not expected to delay the Vanguard launchings to any appreciable extent, as many test-firings have to be made before the complete 3-stage rocket can be made ready. It is hoped, nevertheless, that a full-scale "dress-rehearsal" with the Vanguard rocket can be made towards the end of the year, though not necessarily with the view to placing the final stage in orbital motion round the Earth. The first launchings of the satellite proper are not expected until next year.

It is not anticipated that reporters, photographers, newsreel or T.V. cameras will be present for the initial



FIG. 5. An artist's conception of the Earth-Satellite rocket about to take off from the launching platform built by Loewy-Hydropress Division of the Baldwin-Lima-Hamilton at the U.S.A.F. Missile Test Center, Cocoa, Florida. The vapour blast at the right of the picture is the stream of exhaust gases, and in the background is the gantry used to place the rocket on the platform

launching, although official films will be released almost immediately. Rear Admiral Rawson Bennett, chief of naval research, would like to see the launching conducted under the same conditions as if Vanguard were a military weapon, not because of any question of security, but simply to ensure that the launching preparations are carried out unhurriedly—independent of any outside consideration and under the most favourable weather conditions.

The Soviet Enigma

Needless to say, a great deal of international prestige is involved in the business of placing the first artificial satellite in a closed orbit round the Earth, and it would be a brave man who would predict whether America or Russia gains the distinction. Although the motives for establishing such bodies in space are largely those of geophysical research, both nations are vitally interested in inter-continental ballistic missiles and need to learn a great deal more about the nature of the atmosphere at great heights. One of the big problems associated with such military rockets is how they will re-enter the atmosphere at speeds of over 10,000 m.p.h. without being consumed by atmospheric friction. The artificial satellites will certainly yield information which will be vital

in this sphere of development. By measuring the rate at which the satellite loses speed and height along its orbital track, due to friction with the tenuous upper air, scientists will be able to calculate the air density between 50 and 300 miles above the Earth. The satellites are expected to burn up, like meteors, upon encountering air of greater density at a height of about 60 miles.

While Vanguard has been designed to exceedingly close limits of performance (the complete vehicle is $2\frac{1}{2}$ tons lighter than the German V-2 rocket), there is a growing belief that the Russian satellite venture is based on a larger ballistic step-rocket having a useful working tolerance. The Soviet intention to launch artificial satellites during the International Geophysical Year was first announced in 1955 by Dr Leonid Sedov at the Sixth International Congress on Astronautics, in Copenhagen, and later confirmed at an international meeting of the I.G.Y., in Barcelona, by Professor Bardin. The only other information on the Russian front is that according to Professor Georgi Pokrovsky, writing in the *Moscow News*, the Red satellite will weigh nearly 100 lb. and have a diameter of 20 to 24 in.

If these figures are reliable, this would confirm the theory that Russia's launching vehicle is appreciably larger than Vanguard, possibly based on a long-range ballistic missile. The 100 lb. satellite (as compared with

America's 21.5 lb.) is an indication of the greater design flexibility that may exist. Vanguard, on the other hand, is the minimum size that can reasonably be expected to establish an instrumented satellite and to be successful every part of its propulsion system and equipment must function with optimum efficiency.

When will the Russians attempt to launch their satellite? That, of course, is anyone's guess, though it would be pleasant, from the Soviet point of view, if the event took place on September 5, for this would mark the centenary of the birth of K. E. Tsiolkovskii—the Russian founder of astronautics.

The author would like to express his thanks to the General Electric Company, the Glenn L. Martin Company, and the Aerojet-General Corporation, for information used in this article.

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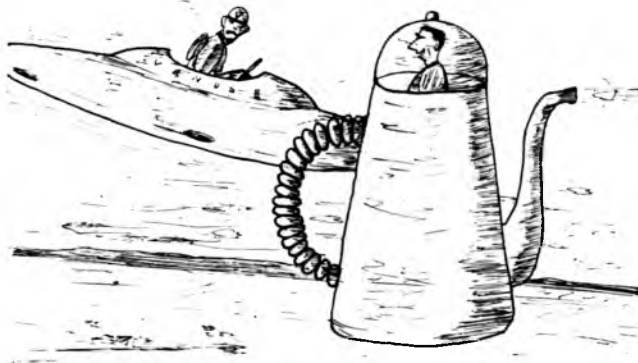
Design-Study by U.S. Engineers

A recent Design-Study by the Advanced Design Department of the Glenn L. Martin Company deals with the feasibility of recovering a scientific payload from rockets which have spent a considerable time above the atmosphere. The project was concerned with a vehicle which will permit the recovery of nuclear emulsions, exposed for a considerable period to primary cosmic radiation. The energies of particles which are present in the primary cosmic radiation are millions of times greater than those which can be produced in laboratories on Earth today, and experiments of this type might reveal the presence of hitherto undetected components of this radiation.

By the use of a three-stage rocket vehicle, designed recently by the Company, it would be possible to expose sensitive emulsion sheets and to recover them for development and analysis. It is considered that a payload of 150 lb. can be projected more than 2,000 miles into space, using rocket components available today. Of this 150 lb. one-third will be required for instruments and the other

two-thirds will provide structure and protection, e.g., heat resistant shell, a parachute for lowering the payload gently to Earth, and a radio-beacon to locate it after landing. In recovering the payload, the emulsions have to be protected from the very high temperatures resulting from re-entry into the Earth's atmosphere and the structure must also be capable of withstanding the high decelerations involved.

The duration of the actual powered flight of the rocket will be less than five minutes, and for the remainder of the trip the payload will be decelerating and re-accelerating in the Earth's gravitational field in free-fall. The payload will spend about 40 minutes above the atmosphere and upon re-entry will attain a top speed of about 13,000 m.p.h.



"I'm afraid he insists on seeing you personally"

Accelerations in Space Medicine

By M. KENNEDY BROWNE, B.SC., M.B., CH.B.

Problems of acceleration: how they affect space-flight, and what is now being done to solve them

Today the conquest of space is the greatest exploration awaiting man. What was not so long ago the realm of fiction is now a practical challenge to all the diverse professions which are associated with the new field of astronautics. For the first time astronomers have joined with scientists, engineers and doctors to tackle a new field of aviation and attempt to solve its difficulties.

Space medicine is associated with many diverse problems which are novel to the medical practitioner of today. Some of these are but simple extensions of the tasks undertaken by the aviation medicine specialists in the past few years, whereas others are entirely new and without precedent. A general discussion of these topics is beyond the scope of a single article and so I will confine myself to some of the basic problems associated with accelerations, a subject which is not new to those interested in aviation and space-travel.

What is Acceleration?

To understand acceleration it is necessary to grasp certain fundamental physical principles. The first of these is a law formulated by Isaac Newton which states that to move a body from rest or to alter the speed or direction of a body moving with uniform speed in a straight line a force must be applied. The change in speed or direction is called acceleration. To take a simple example, when a motor-car moves from rest then it undergoes acceleration, in this case a linear one. Similarly when a car turns a corner, although its speed may remain the same, it undergoes acceleration by reason of its change in direction; in this instance we call the acceleration radial or centripetal since it is towards the centre of a circle.

The second principle was also stated by Newton and is that whenever a force is applied to a body there occurs an equal force in the opposite direction due to inertia. Thus in the case of the car moving from rest there is a force trying to keep the driver stationary and so he feels himself pushed against his seat. Similarly when a car turns a corner there is a force opposite to the centripetal one pushing the occupants to the outside of the car; this force we call centrifugal force. Centrifugal force can be shown quite simply by swinging a stone on the end of a string; if we let go the string the stone flies away at a tangent due to centrifugal force.

Another type of acceleration is that due to gravity. All bodies on the surface of the Earth are attracted towards the centre of the Earth by a force called gravity. Thus, if we jump from a wall or diving board we are pulled rapidly to the Earth by gravity; the change in

speed which we undergo when falling is the acceleration due to gravity and is about 32 ft./sec.² or 1·0 g. Although we only experience this acceleration when falling, the force is acting upon us all the time and also on the floor on which we stand, and it is this force, which we call weight, which pulls us down. Since our weight is really a force accelerating us downwards, then if we can increase this downwards acceleration we will weigh more or conversely if we can partly cancel out gravity by applying an acceleration in the opposite direction, then we will appear to weigh less. It is these changes in acceleration which are important in space medicine.

Effects of Acceleration

For convenience we measure acceleration in "g", that is the number of times it is greater or less than gravity. Thus 3 g means an acceleration three times that of gravity which if acting from head to foot would make us weigh three times as much. When acceleration is in that direction we call it positive and if it acts from feet to head negative; in addition, transverse g means an acceleration acting through the body from back to front.

We can study the effects of positive and negative g on the human body by means of the human centrifuge (Fig. 5). The subject is placed in the gondola at the end of the arm with his head towards the centre for positive g or vice versa for negative. When the centrifuge swings round he experiences centrifugal force which gives him an acceleration which we vary by the speed of rotation of the arm. In the human centrifuge at Farnborough up to 30 g can be produced experimentally in this way. For the study of transverse g a rocket-powered sled running on rails is used and by this means Col. Stapp of the U.S.A.F. has reached values of 50 g for 0·02 sec.

What are the effects of these accelerations? The effect of positive g is to make the whole body weigh more and when values of 6–7 times gravity are reached it becomes difficult to move arms and legs, while if one is wearing a space-helmet the head cannot be lifted at all. More important, however, is the effect on the blood circulation. The increased weight forces the blood from the upper part of the body into the abdomen and legs and although the heart works its hardest it cannot keep supplying blood to the vital structures in the head. The first effect is that the blood supply to the eyes becomes so little that the sight is gradually lost, giving what we call greyout and then blackout; if the g continues or is increased then the blood supply to the brain ceases and consciousness is lost—if this is continued then death occurs due to the brain not getting sufficient oxygen brought to it. In the

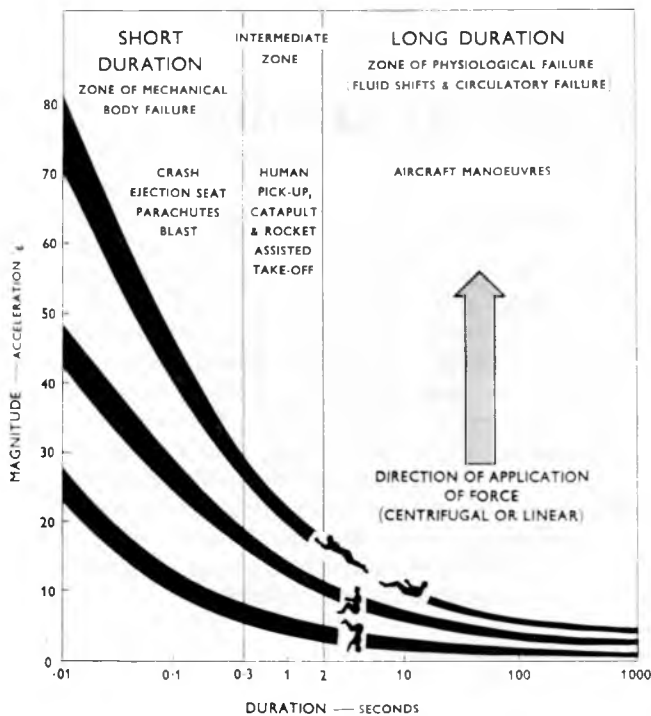


FIG. 1. Anatomical and Physiological limits for acceleration in relation to duration and axes of the body

normal person who is unprotected greyout occurs at 3–4 g, blackout at 4–4.5 g and unconsciousness about 5 g.

When negative g is applied the opposite occurs, all the blood from the lower part of the body is forced into the head and first of all the subject cannot see due to the amount of blood in his eyes, this is called “red-out.” If this is continued then hæmorrhages occur in the head and again consciousness is lost and in a short while death may occur. Red-out commonly occurs at about 2–3 $-ve$ g .

The effects of transverse are not so striking; there is oppression in the chest, breathing is difficult, and if the g is high enough broken bones might result and possibly death from asphyxia. The limits of tolerance of the human body found in the above experiments are shown in Fig. 1. It will be seen that apart from the peak g reached the duration of application of the acceleration is important. Thus although 2 g can be withstood for several hours, blackout and unconsciousness ensue after only 1 sec. at 10 g . Another important factor is the axis of application of g . In Fig. 1 we can see that much higher positive g can be borne than negative and for maximum protection we must lie on our faces or back in which position we can withstand almost twice as much as when seated.

How can we apply these findings to the problems of space travel?

Accelerations in Spaceflight

In spaceflight we are concerned with two extremes of acceleration. The first is encountered in take-off and ascent, where high peak accelerations occur and also long

durations of lower g . The second occurs once we are in space or coasting freely in an orbit round the Earth, as in an artificial satellite. Here we have no acceleration acting at all. In order to maintain constant height above the Earth the satellite must travel in an orbit such that the centrifugal force acting upon it exactly equals the force of gravity. In this situation the contents of the satellite both human and inanimate will experience no acceleration due to gravity, in other words they will be weightless, the state of zero gravity.

To estimate the accelerations which will be involved in launching a spaceship and carrying it to its destination we can study what is known to occur in the rockets in common use today, namely the Aerobee, V-2 and Viking. The types of acceleration involved are shown in Figure 2 with the altitude reached. However, to extend further from the Earth and say establish a satellite with a two-hour orbit of the Earth a rocket must reach an altitude of 1,070 miles with a velocity of 23,000 ft./sec. With present rocket fuels it is most unlikely that this could be achieved by any single space-craft and so we must consider a multi-stage design. The most likely is a three-stage spaceship—each stage increasing the velocity until its fuel runs out and then being jettisoned as the next stage takes over. This rather complicates the acceleration pattern evolved. Initially at take-off the ship is heavy and the acceleration is not too high, however, as fuel is used up and the ship becomes lighter then the same thrust gives increasing accelerations up to a peak at the time of cut-off of the first stage. At this point the acceleration will fall as the ratio between weight and thrust is again high, and so the cycle begins anew. The calculated figures for such an ascent are shown in Figure 3. From what has been said above it is obvious that the

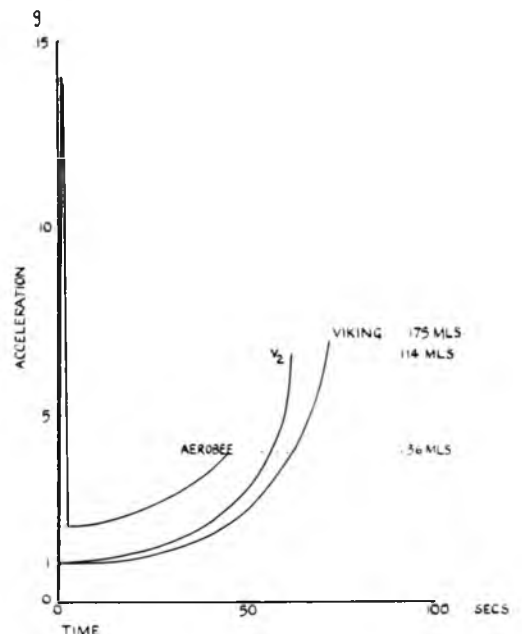


FIG. 2. Graph showing accelerations developed by modern rockets and the heights reached by them

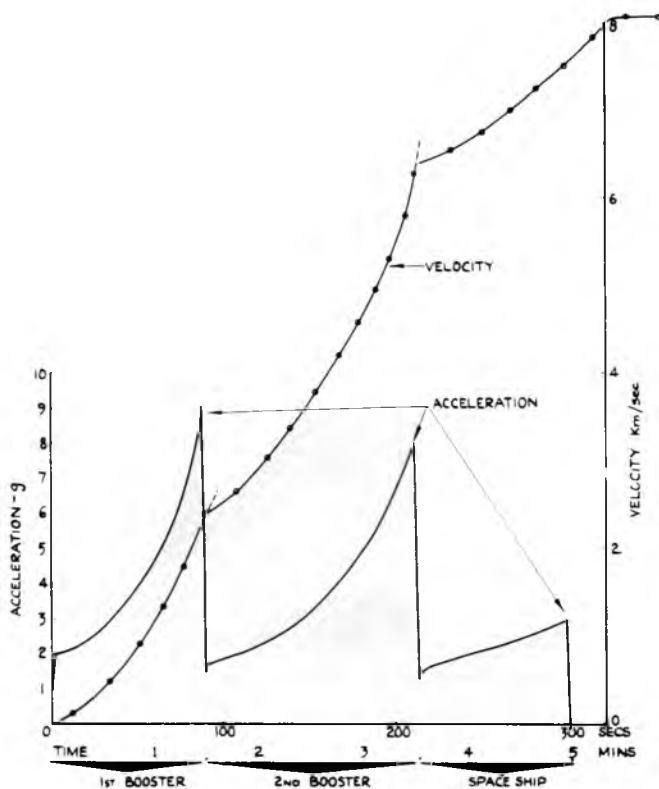


FIG. 3. Diagram showing type of acceleration time curve which would occur in a spaceship reaching a 2-hr. orbital velocity

danger points are the sharp peaks which would stretch human tolerance to the utmost even in the prone position. Thus the best system for the engineer is not a happy one for the doctor. A possible way round this problem would be to throttle back the motors as each stage progressed and so maintain a better weight thrust ratio. This, of course, would necessitate each stage being somewhat longer. If the accelerations could be kept constant then the g time patterns to reach escape velocity are shown below.

Equivalent accelerations and durations to reach escape velocity

1. 3 g 9 min. 31 sec.
2. 4 g 6 min. 45 sec.
3. 5 g 4 min. 45 sec.
4. 6 g 3 min. 48 sec.
5. 7 g 3 min. 10 sec.
6. 10 g 2 min. 6 sec.

Of these figures the first is the one placing least strain on man and the last is completely impracticable so the engineer must strive to design a rocket whose characteristics approximate to case 1. At present this is likely to be impossible, so a crew-carrying spaceship must await the development of equipment giving more reasonable degrees of acceleration.

Weightlessness

As has been mentioned above the other type of acceleration which poses a medical problem is the one of zero gravity when weight as we know it ceases to exist. The body has no attraction to the spaceship or Earth and can float freely in the cabin. This is a condition of which so far we have little experience. Until recently it was something which we could not reproduce experimentally and so was a field of pure speculation. However, with modern jet and rocket aircraft we can study the phenomenon of weightlessness for a limited period of time. To put it simply, the theory is that to experience weight we must have a support pushing against us to prevent us following the force of gravity. Even when falling freely we have some such support, namely the frictional drag of the air. If we dive in an aircraft, however, such that our thrust overcomes this drag, then we have zero gravity. By this means weightlessness lasts but a short time and in practice another manœuvre is adopted. If an aircraft flies a curved path such that its acceleration downwards equals 1 g then centrifugal force will equalize gravity and the occupants will be weightless. This is done by diving the aircraft to gain a high initial velocity and then commencing to climb with just enough thrust to equalize the drag; if this is continued a parabola is described with zero gravity, which lasts about 40 sec. in a jet and up to 3 min. in a rocket aircraft such as the Bell 1-A.

What physiological effects does weightlessness have? This is difficult to say and attempts to answer the question lead to speculation. Eating and drinking should present no difficulty since they can be carried out in any position, even standing on one's head. Neither should the heart nor circulation of the blood be affected as these depend very little on gravity.

Perhaps the most serious foreseeable disturbance will be of the organs of balance, the otoliths. These organs lie in the skull at the level of the ears and consist of little pea-like structures surrounded by hairs. As these little stones are pulled down on to the hairs by gravity, they tell you, "This is down," so when you bend forwards they press on the hairs in front of them and tell you your face is pointing



FIG. 4. The effects of positive g on the facial tissues: (a) subject before run, (b) during exposure to + 4 g

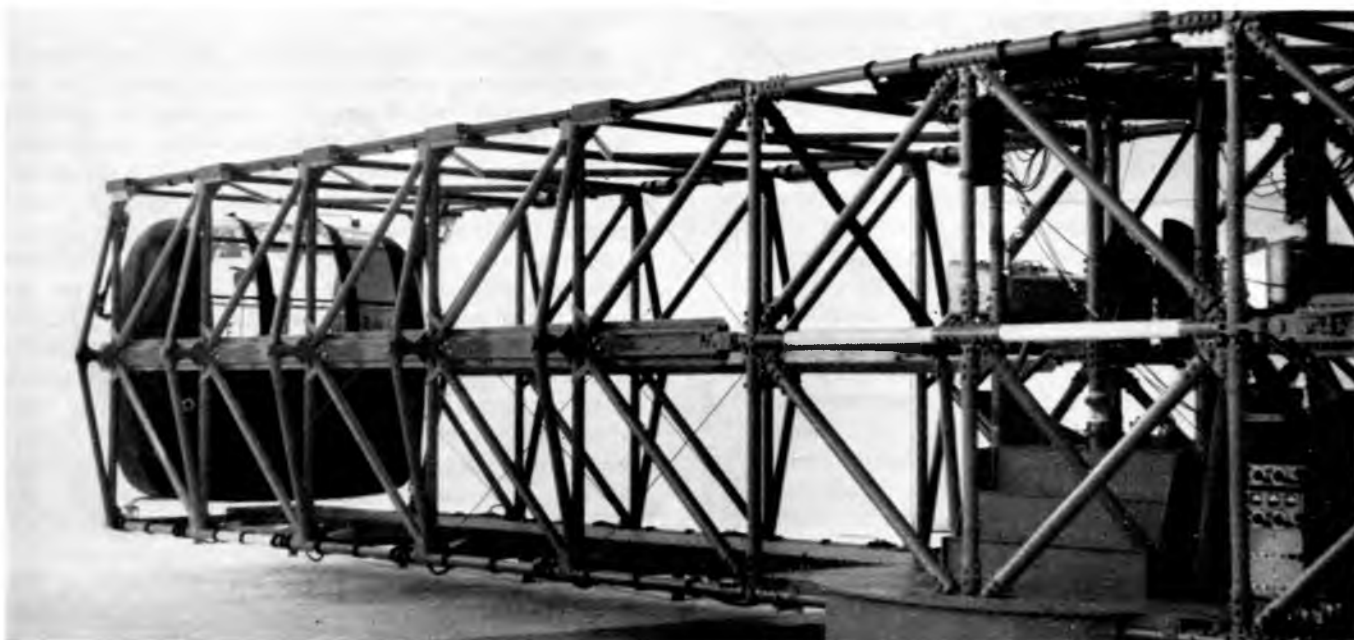


FIG. 5. The arm of the human centrifuge at the R.A.F. Institute of Aviation Medicine, Farnborough

downwards. In a state of zero gravity these little stones will also float freely and touch on hairs at random so giving a variety of sensations, e.g. that you are spinning or falling head over heels. How this will affect space-travellers we can only guess. The most likely result will be violent motion sickness and inability to operate the controls, although there is the possibility that the eyes, by giving the correct information will over-ride the otoliths and allow some sense of balance to be retained. American scientists have demonstrated these effects on animals. In one experiment two mice were sent aloft in a V-2 rocket; one mouse was normal while the other lacked these organs of balance. During the period of weightlessness the normal mouse was badly disorientated while the other, accustomed to a life without a full sense of balance, reacted much better. These animals subsequently suffered no ill effects although admittedly they were weightless for a mere three minutes as compared to hours or days when man first ascends to these heights.

A further problem of weightlessness is in muscular movements. Normally one's movements are performed against a background of gravity—when this is no longer present movements will tend to be erratic, too much or too little movement will take place and similarly the force used will be unsuited to the task. Man's adaptation being what it is, however, this should be a fleeting disability as he will rapidly learn the degree of movement and force required. In the experiments carried out in aircraft this was the commonest complaint. Pilots found they "overreached" their controls and found difficulty in judging fine movements, some also discontinued the manoeuvre due to queer sensations and disorientation. However, adaptation has been shown by giving subjects under zero gravity a task of drawing. In all cases the drawing improved markedly with succeeding runs.

Thus weightlessness as far as we know carries no serious danger to life, yet it causes disorientation which is a most serious disability if we expect the crew to play any part in controlling the ship. However, we need more evidence before being in a position to fully evaluate the zero gravity state.

Other Problems

Apart from these two important and interesting problems, minor ones also occur. Another type of acceleration is angular acceleration. This is what occurs when one spins with a small radius as for instance spinning in a swivel chair. From observation of the V-2 and Viking it appears that these rockets spin fairly rapidly and unpredictably on their upward flight and simple analogy shows what the effect of this might be on the human body. If you spin round and round while standing in the one position and then stop, what happens? Everything else in the room appears to spin and you probably feel giddy. If you now try to pick something off the floor or table you experience great difficulty in doing so. This is what would happen in the rockets of today only to a greater degree. If the spinning occurs at right-angles to this, that is if the crew were seated in the spaceship, then spinning would be round an axis fore and aft through the body at the lower end of the chest. In this situation consciousness is lost fairly quickly and death might even occur. Although spinning is obviously a serious hazard it is one which can be avoided by design, and in the future rockets will require to be stabilized.

These are the main acceleratory problems affecting man in his conquest of space. None present an insurmountable barrier. It would seem therefore that other medical problems and ones of design will be the factors delaying the take-off of the first space traveller.

The B.I.S. Observatory

By LEONARD S. STRICKSON, F.R.A.S.

An account of the British Interplanetary Society's first astronomical observatory

We have several amateur astronomers in the Yorkshire Branch, and we thought it would be desirable to have an observatory in order to serve as a focal point for members with similar interests. In addition it is felt that there is a link between Astronautics and Astronomy, particularly in the lunar and planetary fields. After a conversation between the author and Prof. F. Whipple in Rome last year, we also decided to form a team to take part in operation "Moonwatch".

The fact that the financial outlay had to be low rather limited our scope. Fortunately we discovered that the Harrogate Corporation might lease an old observation tower. Thanks to close co-operation between Mr. L. J. Carter, the B.I.S. Council and the Harrogate Corporation, a lease was drawn up at a purely nominal rental. All that remained was for us to inspect the premises and commence work.

The tower, which is 15 ft. square, is of stone, and is 80 ft. high. It was built in 1829, and stands on the top of Harlow Hill, 600 ft. above sea level on the western boundary of the town. There is no industrial haze, and no great amount of street lighting in the vicinity.

Since being used as a Home Guard H.Q. during World War II the building has been disused, and on entering the cobwebby gloom we found that a horde of pigeons had been using the place as a mass-production hatchery. As soon as we entered we were smothered with clouds of dust and dirt blown down by the beating of wings of the birds we disturbed. The stone steps were lost under a ramp of droppings, and we had to pick our way over nests of fledglings. There is a room off the first landing measuring 18 ft. $\times$ 10 ft.; here the window was boarded up, the ceiling completely down and shrouds of cobwebs hanging on the walls like coats in a cloakroom. Our first task was to get rid of the debris, and we are grateful to Mr. Bishop, Superintendent of the Parks and Gardens Department, for taking loads of rubbish off our hands. After some acrobatics by candlelight, the author managed to put up some temporary wiring for a supply of electric light; then Mr. Waddington, another member, completed the lighting and power circuits.

At this stage there was some doubt amongst certain of our members that perhaps we had taken on too great a task, but the working party was only spurred on to greater efforts by such pessimism. We had a firm of slaters to repair the roof of the "library", as we decided to call the shambles of a room, and we fixed plaster boards to the rafters. Then Stephen Keeler spent his annual holiday decorating and laying lino. He has done one wall over with blackboard paint surrounding a

projection screen. With the addition of some easy chairs and some special curtains woven by Colonel Stephenson, we have a very comfortable headquarters. We even have a camp bed for the more enthusiastic of the night watchers. The curtains deserve special mention, since the design is based on the B.I.S. badge, and the curtains look very effective. Another of the Colonel's activities is the installation of a Foucault Pendulum.

Our next main difficulty was the question of providing a suitable base for the telescope mounting and drive. The inner part of the building consists of a tower 18 in. thick and 8 ft. square. This structure is 13 ft. shorter than the main building. The problem was to build a rigid structure 13 ft. high on a hole 70 ft. deep, 6 ft. $\times$ 6 ft. It seemed that we would never be able to make a first-class job. Fortunately Mr. T. S. Lucas, of Concrete Ltd., Leeds, heard of our problem, and offered to help. After



FIG. 1. Harlow Tower



FIG. 2. L. S. Strickson



FIG. 3. Stephen Keeler,
our decorator



FIG. 4. Group gathered round the base of the tower: L. S. Strickson and Colonel Stephenson in the centre

inspecting the site he produced a design of a concrete and steel structure which surpassed our expectations. One cold and foggy Sunday morning Mr. Lucas arrived with eight men and a lorry-load of equipment. A diesel winch was installed in line with the door of the tower, and the cable taken to the top to block and tackle. With this all the concrete slabs, steel pillars and buckets of cement were hauled up. Firstly the top of the inner tower was covered with concrete slabs; these were reinforced along the joints. Then this platform was covered with 4 in. of concrete over a lattice of $\frac{1}{2}$ in. diameter reinforcing bars. Bolted to this is the steel pillar. This is fabricated from $\frac{1}{2}$ -in. steel plate and is 12 in. square. The pillar is in two sections since it was impossible to get a 13-ft. pillar into the building. The two sections are flanged and joined with $\frac{1}{2}$ in. bolts. To prevent vibration there are four dampers of 2-in. angle iron running from the pillar to the outer walls. The top is furnished with an 18-in. square platform which will take the actual mounting. This platform is capable of a limited movement in any plane in order that we may obtain perfect alignment before bolting it permanently in place. Mr. Lucas and his staff worked all day to finish the installation, and we are indeed grateful to him. Astronomers who have visited us recently have expressed approval. The winter months slowed down our activities; however, during this time we cleaned down the stonework and mixed about 5 cwt. of cement, with which we did some necessary inside pointing. Thanks are due here to Messrs. Greenwood and Gregory, who came over from Leeds every week-end and assisted in the cold and rough task. Gilbert Fielder designed the dome and Michael Wright furnished us with the necessary working drawings. Messrs. Rowley and Metcalfe are well ahead with the mounting and drive and we hope to have that in position in a week or two.

Our next large task was the removal of a heavy wood roof over the observation platform. This was the cause of some careful thought, since none of us are steeplejacks and the thought of working outside at a height of 80 ft.

was not without its terrors. However, the author, with the aid of two volunteers roped together like Alpine climbers, removed the roof in one afternoon. The next week we had the pleasure of threading 15-ft. joists down into the tower in the pouring rain.

The top is now cleared, and work has commenced on the construction of the shuttering for a 14-ft. diameter reinforced concrete ring 6 in. $\times$ 12 in., which will house the eight rollers 6 in. diameter, on which the dome will rotate. The framework of the dome will be fabricated from standard steel sections and the covering material will be 16 s.w.g. aluminium alloy sheet which we are obtaining at cost through Mr. Rowe of Blackburn and General Aircraft. It is hoped that by the time this article appears in print we shall be nearing completion of the main work. The telescope, which has been donated by Colonel Stephenson, is an f 12 Newtonian 6-in. Reflector. The work done and the progress made could not have been achieved without a great deal of help from B.I.S. members and others, and to all those not already mentioned may I say "thank you".



Britain's Guided Missiles and Rockets

By MAURICE ALLWARD

Much has been heard of American rockets; but Britain too, is active in the field of rocket research, as is shown in this article

To write an article on British rockets is not easy, for two main reasons. First, compared with either the United States or Russia, our efforts are relatively small. Secondly, much of the more interesting work we have done is still deeply shrouded under the cloak of security restrictions.

However, the basic philosophy of British Rocket policy is becoming clear, and, if the details of the practical work which have been released over the last decade are gathered together so they can be read in a few minutes, they have the semblance of some impressiveness.

To those interested in "firsts", Britain can claim an important one in the field of guided missiles for, in 1916, the Royal Aircraft Factory, H. P. Folland and the late Professor A. M. Low combined to develop what is sometimes called the first guided missile. This was a small radio-controlled monoplane carrying an explosive charge. To conceal its real rôle of flying bomb it was known as the "Aerial Target".

By 1927 the techniques of radio control were sufficiently advanced for the remotely-controlled Larynx, another small aircraft, powered by a Lynx and fitted with a warhead, to be tried out in Iraq. Three years later the much improved de Havilland Queen Bee was in service with the Royal Air Force as a radio-controlled target drone which, apart from the lack of a warhead, had all the basic qualifications of a guided missile.

However, these interesting "prototypes" were not what one brings to mind upon hearing the contemporary term "guided missile" and for these we have to wait until the close of the 1939-45 war. To put the part to be played by guided missiles into proper perspective a recapitulation of the developments in the air since the war may be of assistance.

The advent of jet propulsion brought with it a radical change regarding the air defence of the United Kingdom. During the war the average fighter had not only a comfortable lead in maximum speed over contemporary bombers, but also a superior service ceiling. This enabled them to attack at will, with the advantage of greater height.

The advent of the jet bomber, however, altered this traditional superiority of the fighter. The fighter advantage

of speed was considerably reduced; its superiority in height reduced even more, if not reversed! This revolutionary change is strikingly illustrated by the fact that the world's official height record of 65,876 ft. is held by a specially engined version of the Canberra jet bomber.

Following closely on the heels of jet propulsion came the dreadful power of atomic and thermo-nuclear bombs. The combination of the two gave a hostile power the means of delivering an annihilating blow virtually overnight.

No longer would it be sufficient for the Royal Air Force to destroy a particular—and fairly low—percentage of enemy bombers, so that their use became "uneconomic". One nuclear bomb, delivered by jet propulsion, could be decisive, so in a future conflict *every* bomber must be destroyed, preferably before it has even reached our shores. There was little chance that this could be achieved by conventional ground or air-borne cannon, even though these were to have vastly increased destructive power compared with those in use during the war.

When the war ended, the government of the day made predictions for the future, and on the basis of these made a grave and serious decision. It was assumed that no new major war would break out for at least 10, and perhaps, 15 years. In the intervening "breathing space" the development of "conventional" armament was to be curtailed, or by-passed, the major effort being directed towards bringing to fruition advanced weapons. It would have been comforting to have developed conventional armament, as more prosperous powers such as the United States and Soviet Russia have done, but Britain's war-strained economy did not permit it here, and the decision enabled us to avoid expenditure on interim equipment which would have soon become obsolete.

One of the advanced weapons envisaged in 1945 was the guided anti-aircraft missile, and during this period much research has gone into the basic problems of such weapons.

In 1946 the war-time Ministry of Aircraft Production was merged with the Ministry of Supply, and the R.A.E., Farnborough, took over the general lead in missile research. Provisional meetings were held to decide upon which problems and types of missile we would concentrate.



FIG. 1. MAURICE ALLWARD

A puzzling feature at this stage of Britain's rocket programme was the apparent indifference of both private firms and service departments to the great wealth of basic missile data captured from the research laboratories of Germany. It may be argued that German missiles were intended for use by and against comparatively slow and low "piston-engined" aircraft, but the author feels that more intelligent use of these data would have hastened our initial developments and probably materially reduced the "three or more years lead" now generally credited to the United States in this field.

As it was the programme virtually started from "scratch" and contracts were placed for several test rockets, each aimed at providing basic data, proving certain items of equipment and establishing correct procedures.

At first the test pieces were small and simple ballistic or aerodynamic research rockets such as the Lop-Gap. These were followed by a complete range of much larger test vehicles as detailed below:

RTV-1	..	Rocket Test Vehicle 1.
RTV-2	..	Rocket Test Vehicle 2.
GPV	..	General Purpose test vehicle.
MTV	..	Motor test vehicle.
CTV	..	Control test vehicle.
RJTV	..	Ram-jet test vehicle.

Of these the first to be exhibited publicly was the RTV-1, an example of which was shown at Farnborough in 1949. A development of the earlier Lop-Gap missile, this was a 17-ft. long bi-propellant surface-to-air rocket (Fig. 2) built for fundamental research into stability and control problems, and for comparative tests on guidance systems. Its maximum speed was around 2,000 m.p.h.

RTV-2 was a bigger, improved, research vehicle, boosted rapidly to supersonic speed by four twin wrapped-boosters, and used primarily for the investigation of control and propulsion problems.

A word here about "boosters" may be of interest. Apart from the RTV-1, nearly all British rockets of which details have been released are accelerated by "wrapped-boosters"—that is, by rockets attached to the side of the missile. This is in preference to the prevalent American practice of using tandem boosters.

A tandem booster can be attached so that the main rocket motor contributes thrust whilst the booster is burning, or it can be triggered to operate when the booster has ceased. Advantages of this system are that separation takes place with the minimum of disturbance to the missile, and that should booster burn erratically (it usually comprises a group of smaller rockets) the out-of-balances forces are relatively small. Also, the booster continues to accelerate its missile as long as it is producing thrust. This arrangement, however, results in a long, unwieldy assembly, with a weight penalty imposed by the air loads of the booster.

With the British method great care has to be exercised to ensure that either all the boosters develop equal thrust or else that their thrust line passes through the centre of



FIG. 2. RTV-1—for research into stability and control problems

gravity and that they separate simultaneously. This often means that the boosters have to be jettisoned while they are still functioning, but the arrangement results in a much shorter missile assembly. This eases servicing and adjustment on the launcher, and the weapon is more manageable in all respects.

The wrap-round booster technique appears to have been developed to a fine art, examples being available of their attachment singly, in pairs and in groups of three. A typical arrangement is eight boosters arranged in four pairs alongside the missile body, each pair resting in the vee formed by the cruciform wings and tail surfaces. The motors of each pair are rigidly connected front and rear by castings which, in turn, are attached to the missile. The boosters slide on from the rear and remain in position as long as their thrust exceeds their drag. When this no longer happens the booster assembly slides rearwards, this action disengaging the front attachment of the units, which then pivot out around a point near the expansion nozzles until a predetermined angle is reached when the rear ends are released allowing them to fall away freely.

The GPV is, as its name indicates, a general purpose research vehicle. Made by Short Bros. & Harland, it is used to obtain data on homing heads, control configuration and liquid or solid "sustainer" motors. Very similar to the RTV-2 in appearance, it has eight wrap-round boosters.

RJTV, ramjet-propelled test vehicles have enabled much data to be evaluated of great value in the development of ramjet-propelled missiles.

This range of research missiles has by now created for Britain a firm foundation of basic missile data. Creditable as this may be, the author feels, as mentioned previously,

that some of the information, laboriously and expensively obtained, was probably "on tap" in German reports had those responsible cared to look.

The change brought about by the "marriage" of jet-propulsion and nuclear weapons made it obvious that Britain's prime need in the operational missile field was something that would hunt out and destroy enemy bombers. It was natural that initial efforts would be directed towards the development of an air-launched missile as the problems involved were somewhat less severe.

Therefore, it was not surprising that the first operational missile to be officially announced, the Fairey Fireflash, was an air-to-air weapon. Fairey Aviation was one of the first British Companies to enter this new field. In order to combat the serious threat of the Japanese piloted "suicide" Baka bombs during the closing stages of the Pacific War, the Stooze, a rocket-propelled interceptor-missile, was being hurriedly developed, but the war ended before these went into service.

An unusual feature of the Fireflash is that the missile itself has no sustainer motor. Two booster rockets, projecting well ahead of the nose of the weapon, rapidly accelerate it to high supersonic speed, after which it continues as an unpowered dart, its own considerable momentum being sufficient to enable it to coast several miles.

For a "first off" attempt this arrangement has a number of advantages, in that the missile is generally simplified. As there is no sustainer motor, there is no rocket flame ionization to affect the guidance system. The Fireflash is guided by what is known as the beam-rider system. Under this system the missile tends to centre itself within a radar beam emanating from an aerial near the point of launching. The radar beam is "locked-on" to the target and automatically tracks this whatever its manœuvres. As the missile is travelling along the centre of the beam, sooner or later it will coincide with the target.

Towards the end of 1953 a prototype Fireflash was successfully fired at an unmanned Firefly, this latter

achieving the honour of being the first target to be destroyed by a British guided missile. Sequences of this, or a similar test, are shown in Fig. 4. Full-scale Service trials with this missile are now being conducted in Fighter Command.

What appeared to be a larger and cleaner version of the Fireflash was displayed on the Fairey Aviation stand at the 1955 S.B.A.C. Show. This was mounted on the front of an American-type tandem booster.

Other firms known to be developing air-to-air missiles include de Havilland and Vickers-Armstrongs. Shown in Fig. 5 is a research vehicle which has featured prominently in de Havilland advertisements. A product of the de Havilland Propeller Co. (Missile Division), from this has been developed the more advanced Firestreak. This employs an infra-red guidance device and is to be fitted to Gloster Javelins and English Electric P.1s.

This method of guidance is one of those known as the "passive homing" kind. Under this heading a missile homes on to a source of energy radiated by the target, such as heat, sound, electricity and magnetic fields. Most important of these is the "heat homer", sensitive to infra-red radiation. Infra-red is the name given to a band of electro-magnetic wavelengths just outside the wavelengths which the eye picks up as visible light. The missile incorporates a scanner tuned to receive a particular infra-red wavelength—for example, that radiated by a hot exhaust jet. The scanner, receiving the radiations, intensifies the signals and passes them on to the missile's control system which functions to keep the scanner in line with the point of maximum radiation. An advantage of this system is that, unlike beam-riding, the signals get stronger as the missile nears its quarry, thereby improving its accuracy. A disadvantage is that, like humans, an infra-red missile cannot see through cloud, but this is not likely to be serious in the case of fast, high-flying jet bombers.

Indications of Vickers-Armstrongs' missile activities have all come from unofficial sources. In October last year a British newspaper reported that: "Another guided missile has been scrapped by the Government. This was being developed for the R.A.F. to replace guns in fighters. The new rocket, scheduled for production soon, has been abandoned because: defence chiefs decided it was too complicated and ambitious; it would have cost too much money in view of the economy drive; the money and manpower was needed for . . . the long-range rocket with the H-bomb warhead. The weapon was being developed for the M.O.S. by Vickers-Armstrongs."

The magazine *Flight* in a review of guided missiles in the issue of December 7, 1956, states that "the position was not quite as described. The Vickers A.M.M. was cancelled not because it was ambitious but because the aircraft which would have carried it was also cancelled." However, there appears more to it than this, for surely, the missile, if worthwhile, could have been carried by other, not necessarily British, aircraft?

Second only in importance to air-to-air rockets and not far behind in development, are the surface-to-air

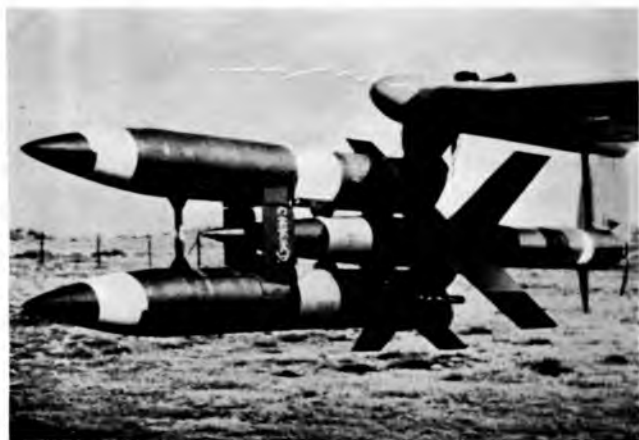
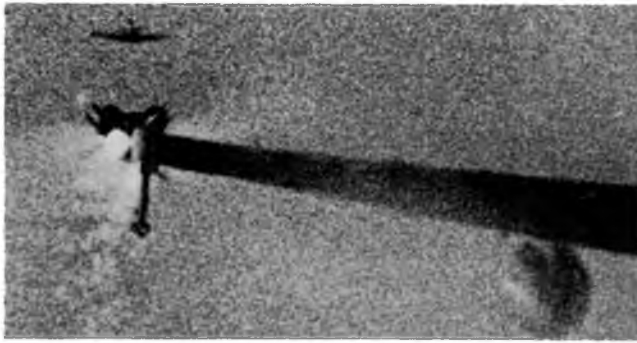
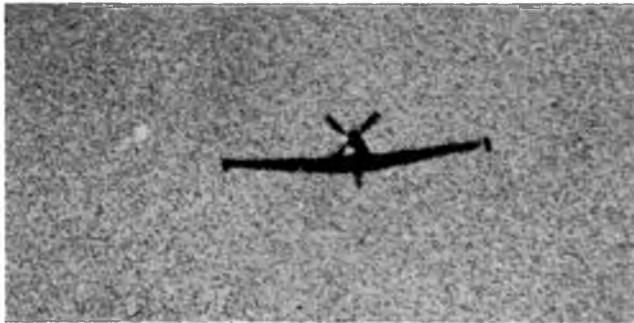


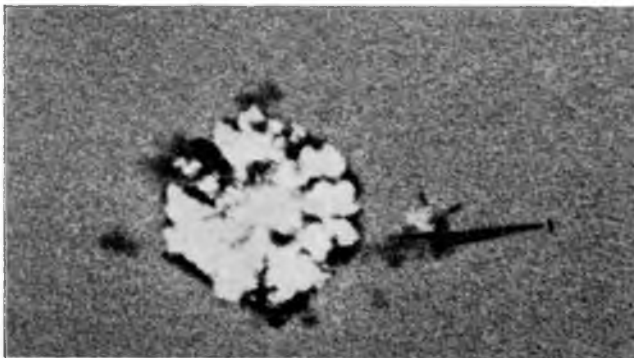
FIG. 3. Fairey Fireflash—Britain's first air-to-air guided missile. It is an unpowered dart, accelerated to supersonic speed by two boosters



(a)



(b)



(c)



(d)

FIG. 4. FIREFLASH KILL

- (a) At the moment of launching. The target drone can be seen above the wing-tip
 (b) Within seconds the boosters have done their job and fallen away. The missile heads unerringly towards the target, guided by an invisible radar beam
 (c) Direct hit!
 (d) The aircraft spins to Earth, on fire and out of control

anti-aircraft missiles. Firms known to be working on these weapons include Armstrong Whitworth, Bristol and English Electric.

Armstrong-Whitworth is the acknowledged fountain-head of guided missile work of the big Hawker Siddeley Group, but all that has been released officially regarding their activities is that they are developing a naval ship-to-air missile boosted by four pairs of wrap-round motors.

Unofficial reports include one stating that this missile is now being tested on the guided weapon ship H.M.S. *Girdleness* and another that it is now nearing production.

First announcement that Bristols were engaged upon guided missile development came in 1949 and today both aircraft and engine divisions are heavily committed on this work. Developments are being facilitated by a technical agreement with the Boeing Airplane Co. Information released so far indicates that development is concentrated on ramjet powered missiles.

Bristol's first production missile is named the Bloodhound and is powered by rockets and a ramjet engine, and guided by Ferranti equipment. Many hundreds of rounds have already been fired in tests.

The Bloodhound is a complete defence system in itself; this is how it will operate. First, radar stations at strategic points around the coast will pick up early warnings of the approach of enemy aircraft. This information will then be passed automatically to the control post of the nearest battery of missiles.

The control post automatically tracks the target and electronic computers assess when it is within range and then send out signals which fire off as many missiles as necessary. It is reported that the system is sufficiently accurate for it to be able to differentiate between one aircraft and two flying in close formation, thus permitting each to be attacked separately!

Third British company known to be developing surface-to-air missiles is English Electric. This company has the advantage of containing within its own organization all the resources required for the development of a guided missile. This includes the "airframe" (the parent company), power plant (Napier's) and guidance (Marconi).

Several photographs have been officially released showing English Electric guided-missiles in flight, and one of these is reproduced in Fig. 6. It has four pairs of wrap-round boost motors and a liquid-propellant sustainer. A small wind-tunnel model (Fig. 7) was exhibited at the 1955 S.B.A.C. Show—noteworthy for unusually shaped tail control surfaces—which may give an indication of the shape of the radar-guided missile which an unconfirmed report of that year inferred was "nearing the production stage". The same report stated that the missile had a ceiling of over 50,000 ft. and that it sped towards its target at over 2,000 m.p.h.

Following the heels—or rather the fins—of the surface-to-air weapons are Britain's surface-to-surface bombardment missiles, for today, more than ever before, possessing the means of attack is, perhaps, the best form of defence. The 1956 Statement on Defence contained the phrase



FIG 5. De Havilland test vehicle. Numerous reports suggest that this missile, or a later version, employs an infra-red guidance device

"particular emphasis is being placed on the ballistic rocket as a deterrent to aggression." But, in this field, even less was released than in the others. About all it said is that "intensive ballistic-missile research is in progress". An unconfirmed report from Washington in 1956 referred to "British programmes for an intermediate range ballistic missile" and announced that "the large liquid-propellant rocket motor which Rolls Royce Ltd. are to make under licence from North America's Rocketdyne Division" would be used in the missile. Another name which has been unofficially connected with the development of an IRBM is English Electric: the report gave a figure of 100,000 lb. thrust for the motor, going on to state that the work was being given top

priority and that it was "hoped the missile would be in production by 1960".

So quickly is top level strategy developing, however, that many 1955 assumptions had become obsolescent by 1956. This was revealed dramatically by the publication in April, 1957, of the annual White Paper on Britain's defence policy. This showed how completely the twin sciences of rockets and nuclear weapons have revolutionized warfare.

Already, it seems, there is little likelihood of another air war being fought with bomber and fighter aircraft. Long-range rockets with thermo-nuclear warheads have rendered both obsolete and, consequently, the R.A.F. is to have nothing with which to supersede its V-bombers and the P.1 super-fighter. The contract for a supersonic bomber has been cancelled; developments of the P.1 will be Fighter Command's last interceptor!

Missiles are to take their place, and to facilitate the change-over, far-reaching agreements have been arranged with the United States, largely dictated by Britain's strained economy. These formed the major part of the agenda at the Bermuda meeting between the Prime Minister and President Eisenhower in March this year, and were the main topic during Mr. Duncan Sandys' visit to Washington soon afterwards. Britain is to receive quantities of American missiles, including a 1,500 to 2,000 mile Intermediate Range Ballistic Missile, to save development time and money, allowing us to concentrate on "more advanced types".

It is known that it will be some considerable time before the IRBMs become available for our use. It can thus be conjectured that our own must be many years away. As *The Aeroplane* stated in its leading article for March 29, 1957, "Though it is true that a heavy miasmic veil of security covers the activities of the companies engaged on the production of guided weapons, it is equally true that when anything worthwhile is produced it is generally expedient from a political point of view to



FIG. 6. English Electric anti-aircraft guided missile immediately after launching against a target aircraft. The wrap-round boosters are still in operation



FIG. 7. Model of English Electric missile exhibited at the 1955 S.B.A.C. Show. Note the unusual shape of the tail surfaces

reveal it. The fact that nothing except rocket test vehicles and training weapons have been disclosed is a reasonable indication that our own IRBM is a long way off." Somehow, sometime, somebody took the wrong decision and activated Britain's programme too late!

Up to a few years ago the intercontinental ballistic missile, with a hydrogen-bomb warhead, was regarded as the "ultimate", or "last", weapon. (Except the late Dr. Einstein, who regarded it as the last weapon—bar one. The final weapon, following the ICBM, according to Dr. Einstein, would be—the stone-age club!) Today, however, there is already speculation about anti-missile missiles, that is, missiles capable of destroying other missiles—particularly IRBMs and ICBMs.

Difficult as the problems may be of "conventional" guided missiles, those of the anti-missiles promise to be infinitely greater—some say impossible. However, at least six American firms are known to be developing "antis", and the 1957 White Paper stated that "nuclear warheads are being evolved for defensive guided missiles" in Britain.

So far this review of British rockets has concentrated on military developments. On the civil research side, Britain's efforts in the high altitude research field cannot be compared with the extensive American programme of the last ten years or so—there is nothing to compare it with!

With the approach of the International Geophysical Year, however, this unfortunate state of affairs is about to be partially remedied. Two research vehicles are under development.

The first, named the Skylark, is 25 ft. long and 17½ in. in diameter. It is powered by a solid-propellant Raven rocket motor 18 ft. long, giving a thrust of 11,500 lb. for about 30 seconds. Fired up an 80-ft. long launching tower, it is designed to reach an altitude of 104 miles—a creditable design aim for a first project. Later improved versions of the Skylark are expected to reach altitudes of up to 120 miles.

Assuming that the proving trials proceed satisfactorily, flights with special data-gathering equipment provided by the British Royal Society will begin in Australia at the start of the International Geophysical Year in July. If the vehicle's performance is sufficiently reliable, some firings may also be made from the Guided Weapons range at Aberporth, Wales.

During these flights experiments to discover further information about the upper atmosphere will be carried out. The apparatus necessary for the proposed experiments is being built by a number of British universities under the general supervision of the Royal Society and the R.A.E.

Tests to discover temperatures and winds at altitudes between 20 and 60 miles will be carried out by photo-electric methods, and winds between 10 and 50 miles up

will be determined by the radar tracking of "window" (strips of tin foil) released from the rocket. Among other factors which will be determined are the nature and abundance of atmospheric ions, measured by a jettisonable nose section of the rocket, and also the density of electrons at various altitudes. Various types of pressure gauges are also being specially developed for the tests.

Summing up, Britain's efforts and achievements in both the guided missile and research rocket fields leave much to be desired. But, bearing in mind the over-riding economic considerations, it looks as if we have, so far, got as good value for our money as *any other country*. Whether this somewhat kind and optimistic observation will hold good in the future, however, only the future will tell.

It is to be fervently hoped that the Bermuda Meeting words referring to Britain's work on "more advanced types" of IRBMs is not typical political phraseology and that for once words mean what they say. For the ultimate goal of all this intensive military research is (assuming that nobody pushes the wrong button during the next dozen or so critical years) manned spaceflight. The nation with an efficient ICBM has the first stepping stone to the planets.

So great a prize must not be allowed to slip through Britain's fingers. If it does the adverse effects on our future history will be with us not for years, but centuries.



Sky Diary: July to September, 1957

By GEOFFREY TURNER, F.R.A.S.

Perhaps the most interesting Summer constellation is Cygnus, the Swan. Although simple in its shape, it is situated on the Milky Way and spreads out over a large area of sky. The general shape is shown in the diagram with its position in relation to other neighbouring constellations. With even a comparatively small telescope, β can be seen as a double star; the brighter component has a magnitude of 3 and the fainter one is just fainter than 5th magnitude. The most interesting thing about this double is its colour contrast, yellow and blue. Apart from its designation β , this star is known as Albireo.

To the west of Cygnus is the very bright star, Vega. It is very conspicuous and hardly needs pointing out; through a telescope it appears a piercing bluish-white. Vega is the brightest star in Lyra, a small constellation with some interesting objects. The star ϵ Lyræ is a famous double-double; it can be seen as double with the naked eye; a small telescope easily resolves it into two components (called ϵ_1 and ϵ_2). Further magnification shows these stars to be elongated, and with moderate powers and resolution the two widely separated components are seen as doubles. Another famous object in Lyra is the Ring Nebula; it is found between β and γ , being rather nearer to β . In a very small telescope it appears as a fuzzy disc of light which, with the greater magnification and resolution of a 6-in. telescope, is shown as a ring of light.

Another prominent star can be seen on the east of Cygnus; it is Altair and is almost in line with Vega and

Albireo. It is the brightest star in Aquila, constellation of the Eagle, although its brightness does not compare with that of Vega.

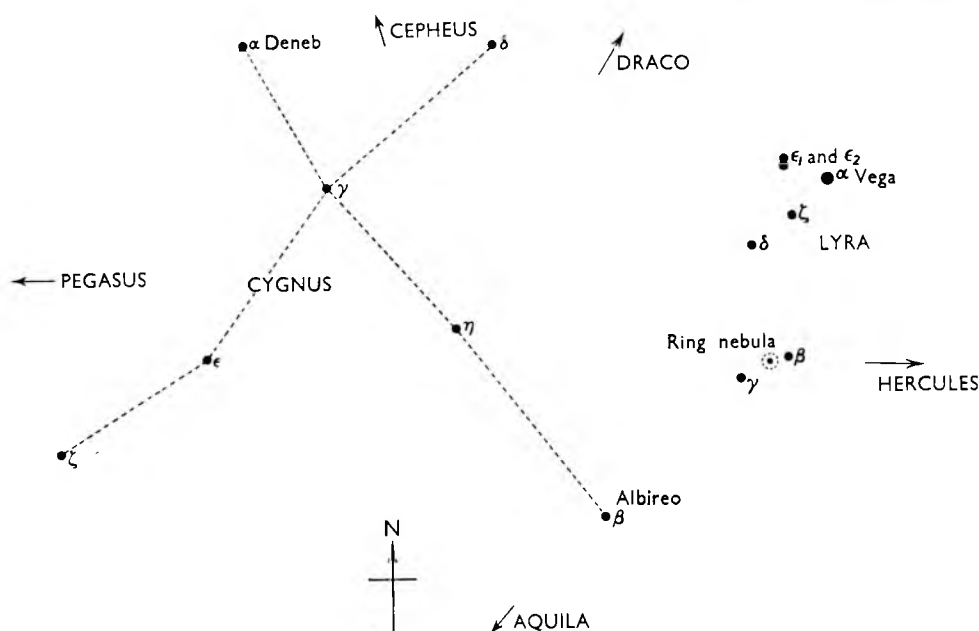
One of the best months of the year for observing the Milky Way is August, when it is overhead in the evenings. On a dark clear night it is a magnificent sight and one can spend an interesting time "sweeping" through this region with binoculars.

Of the planets, Mercury is difficult to observe because it is so close to the Sun. In the middle of July, it sets about three-quarters of an hour after the Sun, and at the end of September it rises about one and a half hours before the Sun for a short time.

During July and August and September, Venus sets about an hour after the Sun. This does not matter, since Venus is so bright, and if it is observed when the sky is very dark, its glare makes useful work impossible. The best time to observe this planet is during the two hours preceding sunset, or following sunrise, when there is less contrast between the planet and the sky background. During this period it brightens slightly from mag. -3.3 to -3.5 .

Mars cannot be observed during this period, since it is on the other side of the Sun. It is, in fact, in line with the Sun and Earth on September 21, when it is said to be in conjunction with the Sun.

At the beginning of July, Jupiter sets at about 11.30 p.m., and at the end of September it sets shortly after the Sun, so that observing conditions for this planet will



deteriorate after July. The antics of Jupiter's satellites were described in the last "Sky Diary", and for those who had a look at them and found them of interest, they might like to look again on July 4, at 9 p.m. G.M.T., when they will all be in a row on the west side of the planet. They can be seen in a row on the east side at the same time on July 14. Whilst on the subject of satellites, one might get the impression that Venus has a satellite on July 6, if it is observed at 9 p.m., since it will appear very close to a star, mag. 6.5. Planets occasionally pass in front of or "occult" stars. If the planet does not quite occult the star, but only comes very close, it is an "appulse", as in this case.

Saturn will be just past its brightest at the beginning of July, when it will be gradually dimming from magnitude 0.3 to 0.8 at the end of September. Also in addition to its diminishing brightness, its apparent diameter will diminish from 16.4" to 14.6". Saturn is usually a difficult planet to observe, since details can rarely be seen, even in big telescopes, and at the present time it is very unfavourably placed for observation in the northern

hemisphere. This unfortunate state of affairs will persist for a few years before it improves. At the beginning of July it will be visible in the evening sky, but will be setting by 8 p.m. at the end of September.

In concluding these notes, I should point out that British Summer Time has no meaning to astronomers, and all the times given are Greenwich Mean Time. Also, if any potential observers wish to become more familiar with the night sky, they might refer to one of the following guides or star atlases:

The Night Sky for 1957: Times Publishing Co. Ltd.

Norton's Star Atlas and Telescopic Handbook: Gall & Inglis.

The Handbook of the British Astronomical Association, 1957: The B.A.A.

Erratum.—It is regretted that a proof-reading slip in the April-June "Sky Diary" resulted in an incorrect date being given for the lunar eclipse. This was given as May 11-12, whereas it should have been May 13-14.

The Comet



This photograph of the Arend-Roland Comet was taken by Bernard Beeston, a member of the British Interplanetary Society, on April 27, using an Agifold camera with an f 4.5, 90 mm. lens and Ilford H.P.S. film. The camera was mounted on a tracking unit, and the exposure was 2 minutes. The faint "reverse tail" extending from the coma, an unusual feature, can be clearly seen.

Cartoonists Corner

R. D. MILLER was born in 1927 and educated at the Salesian College; he has served in the Fleet Air Arm, and joined the British Interplanetary Society in 1950. One of his hobbies is crossword puzzles. It will be interesting to see whether he can produce a multi-dimensional crossword for mental relaxation under conditions of free fall.

PETER J. CATTERMOLE, born in 1939, is in the Civil Service (as a draughtsman), as can be clearly seen from the tea theme of his cartoon on page 138. He is a member of the Lunar Section of the British Astronomical Association, and has contributed to its published work, as well as playing an active part in the Mercury and Venus Section of this Association.



R. D. MILLER



PETER J. CATTERMOLE

Correspondence

SIR.—In a new book, *Space Encyclopædia* (Artemis Press, 1957), there is a statement which should, I feel, be challenged, as the book is an authoritative one and is written by a panel of eminent scientists. The article on "Space Stations", signed by M. T. B. (M. T. Bizony) states categorically that stations of the manned type are not, and never will be, of the slightest use. This view is supported by the contentions that such a station would be "ludicrously uneconomic", that it will be of no military value, that a large number of relay stations could be built for equivalent cost, that it will not be needed for orbital refuelling since this process will by then be obsolete, and that it will not be needed for the erection of an astronomical or physical observatory, since such an observatory will be far better constructed on the Moon itself. The article ends by saying that before manned spaceflight can be attempted, space-stations will "have joined the Channel Tunnel and the Sun Gun in the limbo of technological white elephants".

I need not stress the questionable statements in the article. The Channel Tunnel, for instance, is no wild dream, as has been shown by recent revived interest in it. But it is not likely that if Mr. Bizony's contentions were valid, research workers of all nations would spend so much time upon considering space-stations. In particular, it is absurd to say that the station will be uneconomic; it will, of course, cost a vast sum, but it will justify the outlay. And not until it has been erected will it be possible to journey to the Moon, at least in the opinion of many scientists.

Dogmatic statements in what is otherwise a most excellent and authoritative book, are to be deplored, and it will, I think, be of value to correct the false impression that has been given.

Yours, etc.,
A. MORRIS.

London, W.C.1.

Mr. Bizony tells me that he is preparing a reply to Mr. Morris's letter, which we will, of course, publish in No. 5 of SPACEFLIGHT. Comments from others upon this interesting topic will be welcome. EDITOR.

SIR,—As the surface of Mars is fairly rugged, travel between one place and another might be difficult. Even air travel offers no easy solution, as the low air density (80 mm. approx.) combined with aircraft of high wing loading (100 Kg/m²) produce excessive landing speeds which preclude all but the most elaborate airstrips.

A possible solution might be found in the use of Airships; their ability to hover close to the ground, and

their ease of control in the light Martian winds (10–20 knots) would offer no landing problems. Although their past record is somewhat marred, modern techniques might reduce the disadvantages.

There may be in B.I.S. an airship enthusiast who could explore the technical side of this idea. If not, please treat it as mere "Mars-shine".

Yours faithfully,
L. H. GROVES.

London, W.11.

If the commonly accepted atmospheric pressure of 83 millibars at the Martian surface is assumed (actually 63 mm. Hg), the landing speed of a glider (or aircraft with power shut off) on Mars would be only 2½ times that on the Earth, because the increased speed due to the rarefied atmosphere is partly offset by the lower gravity. Von Braun's latest scheme for landing on Mars is a glider of 450 ft. span and 24,500 sq. ft. area, weighing 63 tons on Mars, with an estimated landing speed of 120 m.p.h. I agree that there is doubt whether the Martian deserts are smooth enough for such a landing.

As to lighter-than-air craft, atmospheric density at the Martian surface is about equal to that at 57,000 feet in the Earth's atmosphere, and manned balloons have gone a lot higher than that. But airships have not, and in working out the weight of added motive power, one must remember that an oxidant as well as fuel must be carried, because fuel cannot burn in the Martian atmosphere. It is to be hoped that some airship expert will work out the required design, which should not be impossible; but it would be a long job, as nothing approaching the required performance has been achieved so far. When built, it would presumably be test-flown at 60,000 ft. before being shipped across to Mars.

A. E. S.

Dr. Gilbert Fielder

G. Fielder, who is a member of the British Interplanetary Society particularly well-known in the Yorkshire Branch (he is shown on the extreme left on the photograph on page 144), has recently gained the degree of Ph.D. from the University of Manchester. His thesis was concerned with the nature of the lunar surface.

We are sure that everyone will wish to join with us in extending our congratulations to Dr. Fielder.

EDITOR.

Reviews

The Men Behind the Space Rockets. By Heinz Gartmann. Weidenfeld and Nicolson, 1955. 182 pp. Price 18s.

This book gives an excellent account of the many trials and tribulations which beset the modern pioneers of the interplanetary idea, and at the same time affords a detailed history of the development of the rocket as a unit of propulsion.

The work is well illustrated throughout by portraits and other photographs, and the first eight of its nine chapters are devoted in turn to Ganswindt, Tsiolkovsky, Goddard, Oberth, Valier, Sänger, Zborowski, and von Braun, with a passing reference to many of the lesser lights with whom these acknowledged leaders came into contact. Of particular interest are the sections which concern the labours of Sänger, Zborowski, and von Braun, wherein there is unfolded much of the inside story of the German Government's espousal of rocket research, and of the unprecedented activity which ensued, in which the author himself played a part.

A survey of the future of the rocket is reserved for the ninth and final chapter, and here a few minor imperfections are to be observed. The present book is a translation from the German (*Traumer, Forscher, Konstrukteure*), and somewhere in the process of a double conversion from English into German, and back into English again, certain quoted passages have not emerged entirely unscathed. There is also a misstatement of fact on page 166, in reference to the founding of the American Interplanetary Society in 1930, an event which could hardly have been inspired by G. Edward Pendray's visit to the German *Raketenflugplatz*, if only because this visitation did not take place until 1931!

P. E. CLEATOR.

Secrets of Space Flight. By Lloyd Mallan. Fawcett Publications, Inc. 144 pp. Many illustrations.

This book consists largely of a collection of photographs dealing with American work on rocketry, high-speed flight, and aero-medical and space medicine problems. The sections on medical research are perhaps the most interesting in that they provide most of the new illustrative material and pay graphic tribute to the courage of those who are preparing the way for Man to travel through space.

The text unfortunately contains some misleading statements. The author's enthusiasm for the work of Dr. R. H. Goddard leads him to declare: "Without him there would have been no science of rocketry today." A caption to one of the photographs contains the phrase: "V-2 was a steal from U.S. rocket made by the man who was ignored: Dr. R. H. Goddard." The author travelled widely to obtain his material, and his enthusiasm for his subject is evident, but the serious reader will find much to criticize.

S. W. GREENWOOD.

Regard the Earth: The International Geophysical Year. By Ronald Fraser. Science Club, 5, Great James Street, London. 2s. 6d.

This illustrated booklet sets out to give a brief, concise account of the forthcoming International Geophysical Year. The reader is told how the plan for the I.G.Y. originated, how the arrangements were made, and why the present time has been selected; there follow sections on the various aspects—meteorology, oceanography, ionospheric physics, cosmic rays, rockets, the Earth's interior, and—last but not least—Vanguard.

The aim of the booklet has been admirably achieved, and the author and publishers must be congratulated upon a most excellent, though necessarily brief, account. The price is

low, and the illustrations are good. There is a Foreword by Sir James Wordie. K. E. S.

Introduction to Astronomy. By Cecilia Payne-Gaposchkin. Eyre & Spottiswoode, 1956. 50s. net. 508 pp.

This book, by the Phillips Astronomer at Harvard University, is arranged in 18 chapters and an Appendix. It is copiously illustrated by diagrams and photographs. The first chapter, the Introduction—Dawn of Astronomy, deals with the remote past: the work of Hipparchus is described; the Zodiacal constellations and signs; a certain amount of mythology; the names of the days, and early notions about the planets, giving a well-balanced account of those distant times. From this theme we pass to the Earth; the lithosphere, the interior shells, how we determine the interior constitution of the globe by means of earthquake waves, the atmosphere and its layers. Mention is made of Eratosthenes' measurement of the Earth. Then follow particulars about the mass, orbit and rotation. The Foucault pendulum is described, and this introduces Precession, leading to the different kinds of years, the seasons and the calendar.

The third chapter, entitled "Tools and Methods", deals with co-ordinates, celestial surveying, time and its equation, the nature of light, wavelength and frequency, radiation, atomic structure and spectra. Then we pass to instruments, lenses, mirrors, types of telescopes, famous telescopes, Schmidt cameras, various accessory equipment, gratings, prisms, transit instruments, special tools for solar research, and other devices. The marvel is that so much has been compressed into this chapter—yet it is easy reading, and contains all the essential facts.

Chapter 4 deals with the Sun, and is illustrated with fine photographs of sunspots, prominences and spectroheliosgrams. The famous sunspot drawing made by Langley in 1873 is also given. This chapter forms an admirable introduction to solar physics. From the Sun we pass to the Moon, and though this too, is an excellent chapter, there are some minor criticisms to be made. It has not been proved that the surface has "a dust layer several inches deep"; neither must the statement that the volume of the interior of a crater is equal to the volume of material in the wall be taken too seriously. It fails for objects such as Clavius and Theophilus. The section devoted to lunar theory might, perhaps, have been a little more extended.

Chapter 6 deals with eclipses; it is rather short, as is the section devoted to the tides. In "The Solar System" we find the Ptolemaic and Copernican theories.

The planets are dealt with in Chapter 8. We may not accept the statement that on Mercury "similar forces have played their part in the formation of the surface as in the case of the Moon", as our actual knowledge of the physical features of Mercury is very limited. On Venus, the facts and theories are presented, and it is shown that although plant life is not impossible, it is unlikely. The section on Mars is distinguished by excellent photographs; the "pros and cons" regarding the canals are fairly presented. The giant planets are discussed, and Wildt's theories as to the constitutions of their globes fully explained. It appears doubtful, however, whether there is a division between the inner bright ring of Saturn and the Crêpe Ring, as stated—Kuiper has not been able to find it.

Chapter 9 deals with the asteroids; the Zodiacal Light; meteors, meteorites and comets, but not at length. There follow chapters on the evolution of the universe and its stellar systems, and the stars themselves. The chapter entitled "Stars—Geometrical Principles", is most valuable, giving such facts as the sequence of spectra, interstellar matter,

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Professor Bates is leading a British team in upper-atmosphere research during the International Geophysical Year.

CONTRIBUTORS:

Arthur C. Clarke, P. E. Cleator, J. Humphries,
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nuclear reactions, sources of energy and internal structure. Variable Stars follow, and this chapter also contains an account of novæ and supernovæ. The globular and other clusters are dealt with in considerable detail, and illustrated with photographs. Then we have stellar systems, galaxies—including our own—with the various theories concerning them, and a review of recent work, the whole forming an excellent summary.

The Red Shift is dealt with, and possible explanations of it are given. Finally we come to evolution, the time-scale, the ages of the Sun and galaxies, and a review of recent researches.

But this most admirable book does not end there. In the appendix we find such data as physical constants and units, the various constellations, and several pages of problems, taking each chapter in turn. The index is adequate, and leaves little out.

There are very few misprints, and the book is an excellent one—an admirable guide to astronomy, valuable as a reference work, and one which should be on the shelves of every astronomer, professional or amateur. H. P. WILKINS.

The Modern Universe. By Raymond A. Lyttleton (London: Hodder and Stoughton, 1956). 207 pp. 16s.

Dr. Lyttleton's book is an astronomical tour through the universe, beginning with the Earth and ending with a description of the cosmological problem of the expanding universe. The book is an extension of a series of talks given by the author on the B.B.C. television programme in 1955. One striking point about this excellent book which is immediately obvious is the wealth of illustration, both diagrammatic and photographic. There are 52 photographs and a beautiful coloured frontispiece of a total solar eclipse. Seven of the photographs are from the 200-in. telescope, and include spectacular pictures of the "Horse's Head" nebula, the Globular Cluster in Hercules and the "Crab Nebula" in Taurus. Amongst the other photographs should be mentioned a fine group of volcanic craters in Java which are compared with lunar craters, a picture of the newly discovered

Ungava meteor crater in northern Quebec, two photographs illustrating the discovery of Pluto, an interesting series showing the apparent decrease in size with distance of nebulae and their associated spectra illustrating the red shift, and several fine photographs of the planets. There are also 61 line diagrams in the text which illustrate and clarify some of the arguments advanced in the book in a most excellent manner. A very pleasing point about the line diagrams is that the text given under each one is complete in itself, so that they can be understood without having to search through the book for explanatory matter, and also a small, but important point is that they are in the correct places and not several pages away from the relevant written matter. In the opinion of the reviewer, the photographs and line diagrams are the finest he has met with in a book of this kind for a long time, and the book is good value for the illustrations alone.

The book itself is not long considering the very wide field it covers. Dr. Lyttleton starts logically by discussing the Earth, including a description of the radio-active dating method and the probable age of this planet. He then goes on to a description of how the Earth's internal constitution is determined by the seismographic method, the origin of the magnetic field, and the Earth's orbit in space. The next section deals with the Moon, and in particular with the origin of the lunar craters and the effect of the Moon's gravitational field on the Earth. We then move to the planets and comets. In this section there is a brief description of each planet and its satellites, if any, followed by sections on comets, asteroids and meteors. The probable origin of Pluto as a one-time satellite of Neptune is discussed, and this whole chapter is written against the background of the probable origin of the Solar System, which problem is discussed later in the book.

Chapter IV goes on to describe the Sun as the only star about which we know very much, and from a discussion of its constitution it is shown how impossible is the idea that the planets were formed from the Sun. The next chapter deals with the stars and the Galaxy, including the description of the probable origin of comets from interstellar dust. This chapter also contains a very clear explanation of the determination of stellar distances using Cepheid variables, a discussion of the origin of planets and, finally, two pages describing radio astronomy. This latter portion is one of the few weak points in the book, and the reviewer would have liked to have read more about the important topic of radio astronomy. The final chapter (VI) deals with the extra-galactic nebulae, including a description of how their distances from us are measured. There is a very clear explanation of Olbers' paradox (Why is it dark at night?) and its relation to the cosmological theory of the expanding universe, which will probably be one of the questions to be investigated using artificial satellites. The last few pages of the book discuss the theory of continuous creation, together with an explanation of why there is no real violation of the principle of conservation of matter.

As will be realized from this brief review, the book is very comprehensive, yet in spite of its shortness relative to the scope, nowhere is it too concise. This is because of its very readable style, and the clarity and simplicity of the author's explanations of difficult points. The author is never dogmatic, and has not only produced a book packed with information but has also attempted to put across the philosophic outlook of the pure scientist, with considerable measure of success. Because it is very readable, this book is strongly recommended to the beginner as an introduction to astronomy, and because of its modern viewpoint and the numerical data often given the book will also be of interest to the expert. It will certainly interest all who read this journal, and is well worth buying.

There is no index, which is a slight drawback, but at the beginning of each chapter is a useful summary of its contents, and at the end of each chapter is a short list of references, mainly to books. The book is well produced and printed, and the reviewer did not notice any printing errors.

N. H. LANGTON.

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